STUDY REPORT

ENERGY ENGINEERING ANALYSIS PROGRAM

WATER CONSERVATION AND LEAK DETECTION STUDY

FORT IRWIN, CALIFORNIA

PREPARED FOR

**DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA**

PREPARED BY

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CONTRACT NO. DACA 05-C-92-0155

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
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Marie Wakefield,
Librarian Engineering

Table of Contents

List of Figures

List of Tables

1.0 Executive Summary

1.1 Introduction

This report contains the results of all work for the Energy Engineering Analysis Program (EEAP) Water Conservation and Leak Detection Study for the National Training Center, Fort Irwin, California. The effort was authorized under Contract Number DACA05-92-C-0155 with the U.S. Army Corps of Engineers, Sacramento District, Sacramento, California.

The purposes of this study are (a) to identify the location of leaks and quantify the magnitude of water losses in both the domestic and reverse osmosis (potable) water distribution systems at Fort Irwin and (b) to develop a plan for water distribution system repairs and upgrades that will reduce water losses as well as energy consumption and operating costs.

1.2 Description of Water Production and Distribution Systems

Raw water is supplied to Fort Irwin from three ground water basins—the Irwin, Bicycle and Langford Ground Water Basins. Underlying and surrounding the Cantonment Area, the Irwin Basin is mined by three active wells supplying the domestic water distribution system and one well dedicated to the reverse osmosis (RO) plant. Located about two miles northeast of the center of the Cantonment Area, the Bicycle Basin is mined by four active wells supplying the domestic system. Located about four miles southeast of the center of the Cantonment Area, the Langford Basin is mined by three active wells supplying the domestic system.

The domestic water distribution system at Fort Irwin is divided into two systems, with the original distribution system supplied by the three active wells located in the Cantonment Area. Water is pumped to a 1,000,000-gallon underground reservoir, from which gravity flow supplies most of the industrial area. The other domestic water distribution system is fed from the two remote well fields through 16-inch lines to booster pumping stations with on-grade storage tanks. The capacity of the Bicycle Basin tank is 500,000 gallons; and the capacity of the Langford Basin tank is 250,000 gallons. Water supply mains extend from the two booster pumping stations to distribution loops in the Family Housing and Administration areas and on to three surface 1,000,000-gallon main water storage tanks. Two of these tanks are located at a higher elevation to serve the Family Housing and Administration areas, while the third tank is located at a lower elevation next to Goldstone Road. A booster pumping station uses the lower 1,000,000-gallon storage tank as a pump well to serve Goldstone Tracking Station facilities.

Feed water for the RO plant is provided by a dedicated well located at the plant. A connection, normally closed, is available from the domestic system should the dedicated well not be available. The feed water is filtered and pumped at high pressure through RO membranes. Chemicals are added and the product is pumped to three distribution system areas. RO water is supplied to taps located in family housing unit kitchens and to drinking fountains located in administrative and industrial buildings.

The three distribution areas are supplied RO water as follows: (1) the original family housing area is fed from a 1,000-gallon hydro-pneumatic tank, (2) the administrative and industrial areas are fed by gravity from interconnected 150,000-gallon and 263,000-gallon tanks and (3) the newer family areas plus some of the older housing and a trailer park in the older developed areas are fed by gravity from a 20,000-gallon tank located on the hillside south of Goldstone Road near the two main domestic system storage tanks.

1.3 Present Water and Energy Consumption

Domestic water production at Fort Irwin currently ranges from a summer peak of 4.6 million gallons per day to a mid-winter minimum of 2.0 million gallons per day. Annual domestic water production has exceeded one billion gallons (or 3,300 acre feet) during the past three fiscal years.

Production of potable, or RO, water by the RO plant totaled 28.8 million gallons during FY96, with average daily production ranging from 62,000 to 91,000 gallons.

A summary of the estimated annual costs of electricity consumption and demand associated with water production and distribution plus operations and maintenance costs for the two Fort Irwin water systems during FY96 is provided in the following table:

Water System	Electricity Demand Cost*	Electricity Usage Cost*	O&M Labor Cost	O&M Materials Cost	Total Annual Cost	Average Cost Per 1000 Gallons
Domestic	$253,508	$188,554	$529,360	$400,000	$1,371,422	$1.2972
RO	$35,855	$68,258	$45,240	$50,000	$199,353	$6.9186

*Estimated quantities since electrical metering is not provided throughout water systems

1.4 Water Conservation Analysis

1.4.1 ECIP Project: Additional Domestic Water System Storage and Well Pump Load Shifting

A project qualifying for ECIP funding that would provide additional domestic water system storage to allow curtailment of water well pumping during peak electric rate periods was developed. Periods of peak water demand coincide with the highest electric rate periods, thus resulting in unit costs for electricity demand and consumption incurred at the highest on-peak rates. Currently, well pumps must be energized during periods of peak water demand since there is insufficient storage capacity to supply all water requirements at Fort Irwin for the duration of the six-hour on-peak period. A new water tank sized at 750,000 gallons will provide sufficient storage to eliminate all well pump operations during the summer on-peak rate period (1200 to 1800 hours.)

1.4.2 Installation Work Requests

Work Request (Form 4283) documentation was developed for two viable low-cost projects to be accomplished by Fort Irwin resources: (1) reclamation of domestic distribution system flushing and fire hydrant test water and (2) a retrofit at the ice plant to pre-cool ice machine feed water and reduce water losses.

<u>Reclamation of Domestic Distribution System Flushing and Fire Hydrant Test Water</u>

All fire hydrants are flowed annually to perform residual pressure tests and a number of hydrants are allowed to flush in order to clear the lines of accumulated silt. It is recommended that this flush and test water be collected in water trucks for use in irrigation and dust control. Implementation of this project will require the fabrication of custom pipe spools, containing fittings for pressure gauges and pitot tubes, to be attached to the top-loading fittings on water trucks.

<u>Ice Plant Water Savings and Pre-Cooling Retrofit</u>

The efficiency of the ice plant at Fort Irwin is reduced significantly by the high temperature of the RO feed water supply, which is in excess of 25 degrees F above the rated supply water temperature of 60 degrees F during the summer months. A project to pre-cool ice plant feed water and irrigate an adjacent area to be landscaped using waste "snow" and cold wastewater from the ice-making process is recommended. The proposed retrofit will consist of a 3,500-gallon heat exchanger tank to collect "snow" and wastewater, ice plant feed water and waste water collection piping modifications, a solar-powered irrigation pump, irrigation piping and landscaping.

A summary of project data for all water conservation opportunities analyzed, including those water conservation opportunities not recommended due to unfavorable economics, is presented in Table 1-1.

1.5 Water Leak Detection Survey Results

The leak detection survey identified 14 water leaks in the domestic distribution system totaling an estimated 100,440 gallons per day and three leaks in the RO distribution system totaling 28,800 gallons per day. The leakage quantity in the domestic system represents only about 5 percent of the average winter daily domestic water production at Fort Irwin, which compares very favorably to distribution system water losses at other Army installations.

Table 1-1
Summary of Water Conservation Opportunity Analyses
Fort Irwin, California

Project Description	Water Savings (x1000 Gallons)	Electricity Usage (kWh)	Electricity Demand (kW)	Annual Savings ($)	Total Investment ($)	Simple Payback Period (Years)	Savings to Investment Ratio
Ice Plant Water Savings & Pre-cooling Retrofit	1,665	81,004	12.8	5,276	30,371	5.76	2.67
Additional Domestic System Water Storage & Well Pump Load Shifting	-	-	787	114,262	827,665	7.24	2.08
Reclamation of Domestic Water System Flushing & Fire Hydrant Test Water	1,582	5,232	2.3	260	2,091	8.06	2.00
Underground Reservoir Repair & 220-Unit Family Housing Heat Pump Cooling Modification	37,522	(20,221)	22.0	(138)	487,261	NA	NA
Reclamation of RO System Flush Water	4,484	66,217	-	(2,279)	11,150	NA	NA
Totals (Recommended Projects Only)	3,247 3.2M	86,236	802.1	119,798 $120k	860,127	7.18	2.10

$$\frac{86,236\ kWh}{yr} \times \frac{3,413\ BTU}{kWh} \times \frac{MBTU}{10^6\ BTU} = 86.236 \times 3.413 = \frac{294\ MBTU}{yr}$$

2.0 Introduction

This report contains the results of all work to date for the Energy Engineering Analysis Program (EEAP) Water Conservation and Leak Detection Study for Fort Irwin National Training Center, California. The work was authorized under Contract Number DACA05-92-C-0155 with the U.S. Army Corps of Engineers, Sacramento District, Sacramento, California.

2.1 Purpose

The primary purpose of this study is to identify the location of leaks and quantify the magnitude of water losses in the two water distribution systems at Fort Irwin and to develop a plan for water distribution system repairs that will reduce water losses as well as energy consumption and operating costs.

2.2 Scope

The scope of work as established by the U.S. Army Corps of Engineers, Sacramento District, consists of the following tasks:

- Limited site investigation of the domestic water and reverse osmosis (RO) water supply systems and water distribution systems in the Cantonment Area
- Instrumented water leak survey of the domestic water and RO water distribution systems in the Cantonment Area
- Evaluation of alternative piping replacement strategies including life cycle cost analysis of each alternative
- Evaluation of water conservation opportunities (WCOs) other than leak repairs and piping replacements
- Evaluation of a water and energy conservation project at the Ice Plant to pre-cool feed water using waste "snow" from the ice making process
- Investigation of a solution to the problem of irrigation water loss due to coyotes digging at sprinkler heads
- Preparation of funding documentation for the recommended projects
- Preparation of a report documenting the data collected, analysis performed and projects recommended

The complete scope of work and minutes of the prenegotiation conference appear in Appendix A.

2.3 Methodology

The sequence of the study, in chronological order, progressed from the site investigation to preparation of the interim report to the presentation and review conference to preparation of the final report. Methodologies used during each phase of the study are addressed as follows:

2.3.1 Site Investigation

The Keller & Gannon two-man investigation team monitored water flows at booster pumping stations and water wells through temporary installation of non-invasive ultrasonic flow meters (Dynasonics, Inc. Model MK3-902) connected to Fluke Model 2635A Data Bucket data loggers. Additional historical pumping records were obtained from the Directorate of Public Works (DPW). Copies of as-built drawings, both hard copies and electronic files, of the domestic water distribution system and RO water distribution system were also obtained.

A two-man team from M. E. Simpson Company, Valparaiso, Indiana, performed an instrumented leak survey of both water systems within the Cantonment Area, consisting of approximately 40 miles of piping. The leak survey was accomplished using the following equipment: a Fluid Conservation Systems (FCS) 90/90 or FCS C2000 leak correlator, an FCS MP90 electronically-enhanced transducer system and an FCS S20 electronically-enhanced listening device. Information on the precise location of all water leaks discovered during the survey was provided to Fort Irwin DPW upon completion of the survey.

2.3.2 Interim Report

The first step in the preparation of the Interim Report was the reduction of data collected during the site investigation and creation of a water supply and distribution system database. Raw water flow data recorded by the data loggers was uploaded to Excel spreadsheets for conversion to engineering units and subsequent totalization and evaluation. Unit costs were then developed for each of the alternative water distribution piping replacement strategies.

Following completion of the databases and development of unit costs, upgrade strategies and water conservation opportunities (WCOs) were evaluated for both water distribution systems according to the scope of work. Spreadsheet software and, where necessary, manual calculations were employed to determine the relative benefits of each upgrade strategy and WCO. Life cycle cost analysis were performed for all alternatives and WCOs in accordance with the latest "Energy Conservation Investment Program (ECIP) Guidance" dated 6 September 1996.

2.3.3 Final Report

Following the Interim Report presentation and review conference, funding documentation was prepared for the recommended upgrade work and WCOs, as directed by the Government review. In addition, revisions resulting from the review conference were incorporated into the Final Report narratives and calculations together with an executive summary.

2.4 Previous Studies

There have been no previous studies concerning water conservation in the distribution systems at Fort Irwin. A sitewide energy study entitled "Fort Irwin Integrated Resource Assessment," prepared by Battelle Memorial Institute and completed in February 1995, included an energy resource opportunity (ERO) to add domestic water storage to allow shifting of well pump loads. This cost-saving ERO has been reevaluated in this study.

3.0 Description of Existing Facilities

3.1 Location, Size and Climate

Fort Irwin National Training Center is located in the Mojave Desert of California about 37 miles northeast of the city of Barstow. Barstow is situated about halfway between the cities of Los Angeles and Las Vegas. The Central Base, or Cantonment, Area can be reached from Barstow by traveling five miles east on interstate highway I-15 and then northward for 36 miles on Fort Irwin Road

Fort Irwin covers approximately 970 square miles and is roughly square in configuration, most of which is desert wilderness. Facilities are located near the southwestern portion of the property, thus allowing training exercises to be conducted free from any restrictions of developed areas. The location and configuration of Fort Irwin is shown in Figure 3-1.

The terrain of Fort Irwin consists of a series of small mountain ranges with intervening drainage basins predominantly consisting of dry lake beds, or playas. The highest elevation is 5,685 feet and the lowest is 1,189 feet. The elevation of the Cantonment Area averages about 2,500 feet.

The climate at Fort Irwin is classified as "hot desert," with hot summers, relatively cool winters, low humidity and frequent strong southwesterly winds. Precipitation as recorded in Barstow has averaged 4.4 inches annually over the past 45 years and generally occurs December through February.

3.2 Historical Water Production

Historical domestic water production at Fort Irwin currently ranges from a summer peak of 4.6 million gallons per day to a mid-winter minimum of 2.0 million gallons per day. Annual water production has exceeded one billion gallons (or 3,300 acre feet) during the past three fiscal years. Approximately 25 million gallons per year are pumped to Goldstone Tracking Station facilities, ranging from a summer peak of 125,000 gallons per day to a winter minimum of 37,000 gallons per day.

Historical production of potable, or reverse osmosis (RO), water by the RO plant totaled 28.8 million gallons during FY96, with average daily production ranging from 62,000 to 91,000 gallons.

Monthly domestic water production for the past three fiscal years (FY94, FY95 and FY96) is shown in Figure 3-2. Monthly RO water production by the reverse osmosis plant for FY95 and FY96 is shown in Figure 3-3.

3.3 Raw Water Supply

Raw water is supplied to Fort Irwin from three ground water basins--the Irwin, Bicycle and Langford Ground Water Basins. Underlying and surrounding the Cantonment Area, the Irwin

Ground Water Basin has a surface area of approximately 7.5 square miles (4,800 acres) and ranges in depth to more than 500 feet. There are currently three active wells (designated I-3, I-5 and I-7) in the Irwin Basin supplying the domestic water distribution system and Well 2A dedicated to the defluoridation plant. Water well locations at Bicycle Lake, Langford Lake and within the cantonment area are shown on Figure 3-4.

Located about two miles northeast of the center of the Cantonment Area and reachable via Bicycle Lake Road, the Bicycle Ground Water Basin has a surface area of approximately 8.1 square miles (5,200 acres) and ranges in depth to more than 800 feet. There are currently four active wells in the Bicycle Basin (designated B-1, B-4, B-5 and B-6) supplying the domestic water distribution system.

Located approximately four miles southeast of the center of the Cantonment Area and reachable via Langford Road, the Langford Ground Water Basin has a surface area of approximately 10.9 square miles (7,000 acres) and ranges in depth to more than 600 feet. There are currently three active wells in the Langford Basin (designated L-1, L-2 and L-3) supplying the domestic water distribution system.

The quality of the ground water in all three basins ranges, in general, between 400 and 600 milligrams per liter of total dissolved solids. Fluoride and iron content are above the acceptable range for potable uses. Locations of all active wells are shown on Figure 3-4; and a summary of well data is provided in Table 3-1.

3.4 Domestic Water Distribution System

The domestic water distribution system at Fort Irwin is divided into two distribution systems. The original distribution system is served by three active wells located in the cantonment area. Water is pumped to a 1,000,000 gallon underground reservoir, the first constructed at Fort Irwin. Gravity flow from this reservoir serves most of the industrial area.

The other distribution system is fed from two remote well fields. Water is pumped from wells in each field through 16-inch diameter lines to booster pumping stations with on-grade storage tanks. The Bicycle Lake installation consists of a 500,000 gallon storage tank and three 200 HP booster pumps. The Langford Lake installation consists of a 250,000 gallon storage tank and three 150 HP booster pumps. Water supply mains extend from the two booster pumping stations to distribution loops in the Family Housing and Administration areas and on to three surface 1,000,000 gallon main water storage tanks. Two of these tanks are located at a higher elevation to serve the Family Housing and Administration areas, while the other tank is located at a lower elevation next to Goldstone Road. A booster pumping station there uses the 1,000,000 gallon storage tank as a pump well to serve Goldstone Tracking Station facilities. A summary of booster pump data is provided in Table 3-2. Water distribution to Goldstone is not in the scope of this effort. Some supplies are re-pumped from the Goldstone system to serve Fort Irwin Corrals and the Pioneer water tank.

The two Fort Irwin domestic water distribution systems are tied together through pressure regulating valves. This allows the Bicycle and Langford Lake systems to serve the cantonment area distribution system in the event that the 1,000,000 gallon underground reservoir system cannot meet

demand. Domestic water distribution system zones are shown on Figure 3-5. A simplified flow diagram of the domestic water distribution system is shown on Figure 3-6.

3.5 Potable (Reverse Osmosis) Water Supply and Distribution System

The reverse osmosis (RO) plant is located in Building No. 44, on Goldstone Road. Feed water for the RO plant is provided by a dedicated well, No. 2A, which is located at the plant. A connection, normally closed, is available from the domestic water distribution system should the dedicated well not be available. The feed water is filtered and pumped at high pressure through RO membranes. Chemicals are added and the product is pumped to three distribution system areas. Brine is wasted to the sewer.

Based on FY 1996 production records, annual potable water production is about 28.8 million gallons. Brine flow wasted to the sewer totaled about 31.2 million gallons and raw water feed totaled about 62.6 million gallons thus, 46% of raw water feed is converted to potable water. The influent (feed) water to the RO plant contains 518 ppm of total dissolved solids (TDS) and the product (effluent) contains 73 ppm TDS, according to a recent analysis. At the current recovery rate, the TDS of the brine effluent is calculated to be at least 936 ppm. After completion of a planned renovation to replace the existing RO membranes with high-efficiency membranes, brine production will decrease and TDS concentration will increase correspondingly.

The original RO plant served only the family housing areas. Reverse osmosis product water is pumped into a 1,000 gallon hydro-pneumatic tank, and then to the service area. The system was expanded to serve the administration and industrial areas from a gravity storage tank of 150,000 gallons capacity. A second, larger tank, of 263,000 gallons capacity, was added recently and connected to the 150,000 gallon tank, to augment storage capacity. The third and newest system is fed from a 20,000 gallon tank located on the hill side south of Goldstone Road. This 20,000 gallon tank serves the newer family housing areas and some of the older housing and trailer park in the older developed areas. A simplified flow diagram of the potable water system is provided as Figure 3-7. Separate service areas are indicated on Figure 3-8.

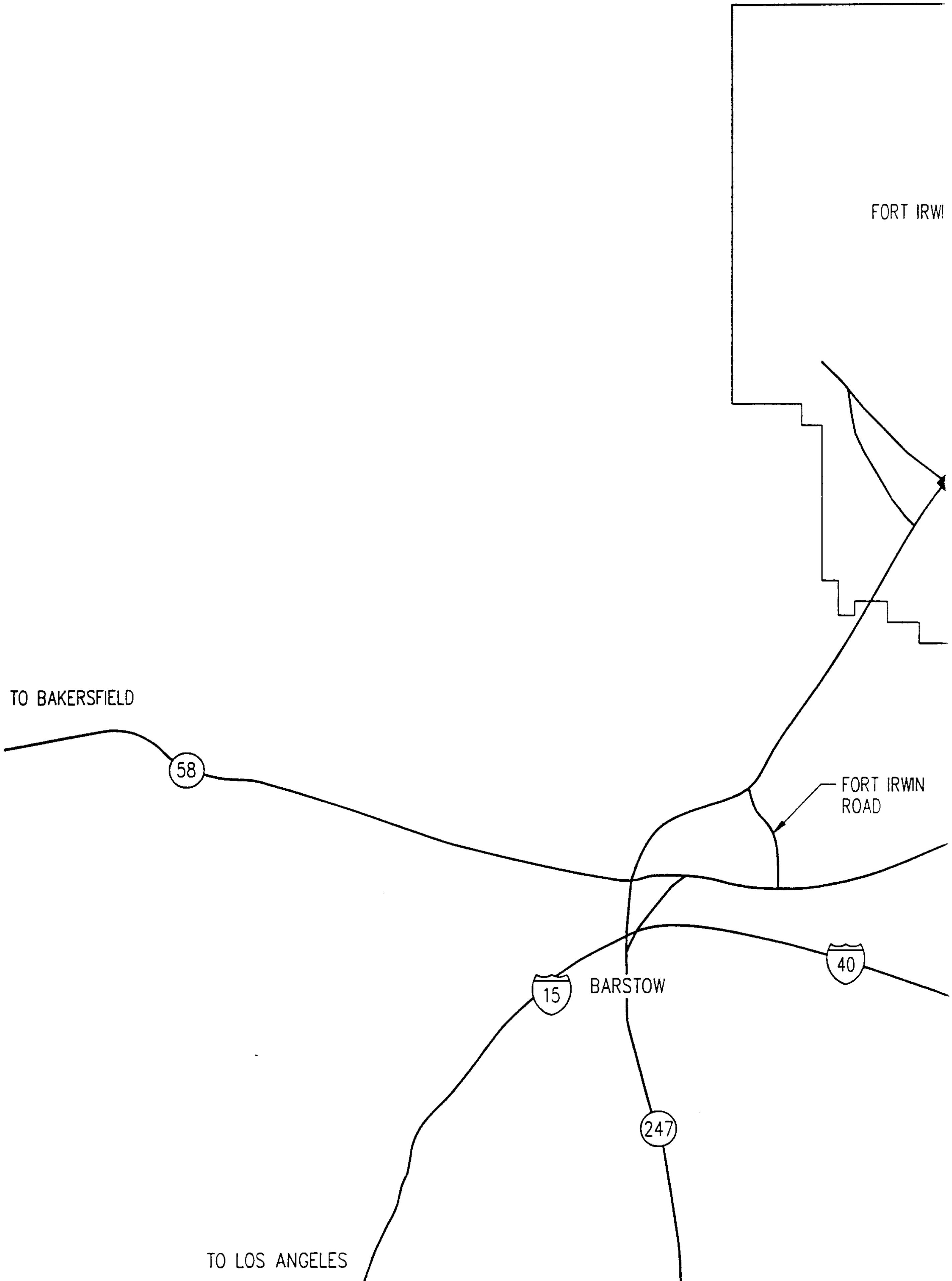
Piping installed for RO distribution consists of a mixture of copper, cement asbestos (AC), galvanized, polyethylene (PE) and polyvinylchloride (PVC) materials. Metallic and AC piping was installed to serve the older housing areas. Most has since been replaced by PE or PVC. Some metallic piping still serves the industrial area. The remaining metallic piping in housing areas is scheduled for replacement with PVC as the housing is renovated.

Potable water is treated using zinc orthophosphate, sodium silicate and sulfuric acid. Prior to distribution sodium hypochlorite is added for chlorination. The orthophosphate and silicate chemicals are used to protect copper piping still serving some of the older housing area. It was found that the pH and chemical makeup of RO water was dissolving and corroding copper, galvanized and asbestos concrete piping at an advanced rate. Some toxic exposures from copper were encountered. The orthophosphate coats out onto the pipe surface, masking it from further corrosion; pH adjustment reduces corrosion as well. While chemical additions protect the piping, the distribution system must be flushed periodically to assure good coating and protection of the interior pipe surface.

3.6 Sewage Treatment Plant

The sewage treatment plant is located on 5th Street, south-east of the cantonment area. The plant is sized for a flow rate of about 2 million gallons per day. Treatment is effected by an extended aeration secondary treatment process. Effluent is chlorinated and then pumped to the abandoned golf course where it is sprayed as irrigation water. Effluent is also pumped to a 22-acre holding pond where it is allowed to percolate into the ground.

Discharge to the golf course will be discontinued to comply with 1992 RWQC requirements. It was found that irrigation there is creating a nuisance condition, thus, Fort Irwin agreed to install a standard percolation system. The percolation ponds will cover about 40 acres, effluent will be disinfected using sodium hypochlorite. UV disinfection is currently being investigated by the Army, because of concern that chlorine compounds may be forming underground due to percolated wastewater. The USGS, in a recent study, concluded that dissolved solids in groundwaters will be increased as a result of wastewater percolation. A new study is being conducted to investigate three alternative wastewater disposal concepts: (1) tertiary treatment of the wastewater with reuse as irrigation water for common areas at Fort Irwin such as playing fields, parks and other grassy areas; (2) locating percolation areas remote to water supply well fields; and (3) desalination with recharge in areas previously used for percolation, now with high dissolved solids.


FORT IRWI
TO BAKERSFIELD
58
FORT IRWIN
ROAD
40
15
BARSTOW
247
TO LOS ANGELES

1

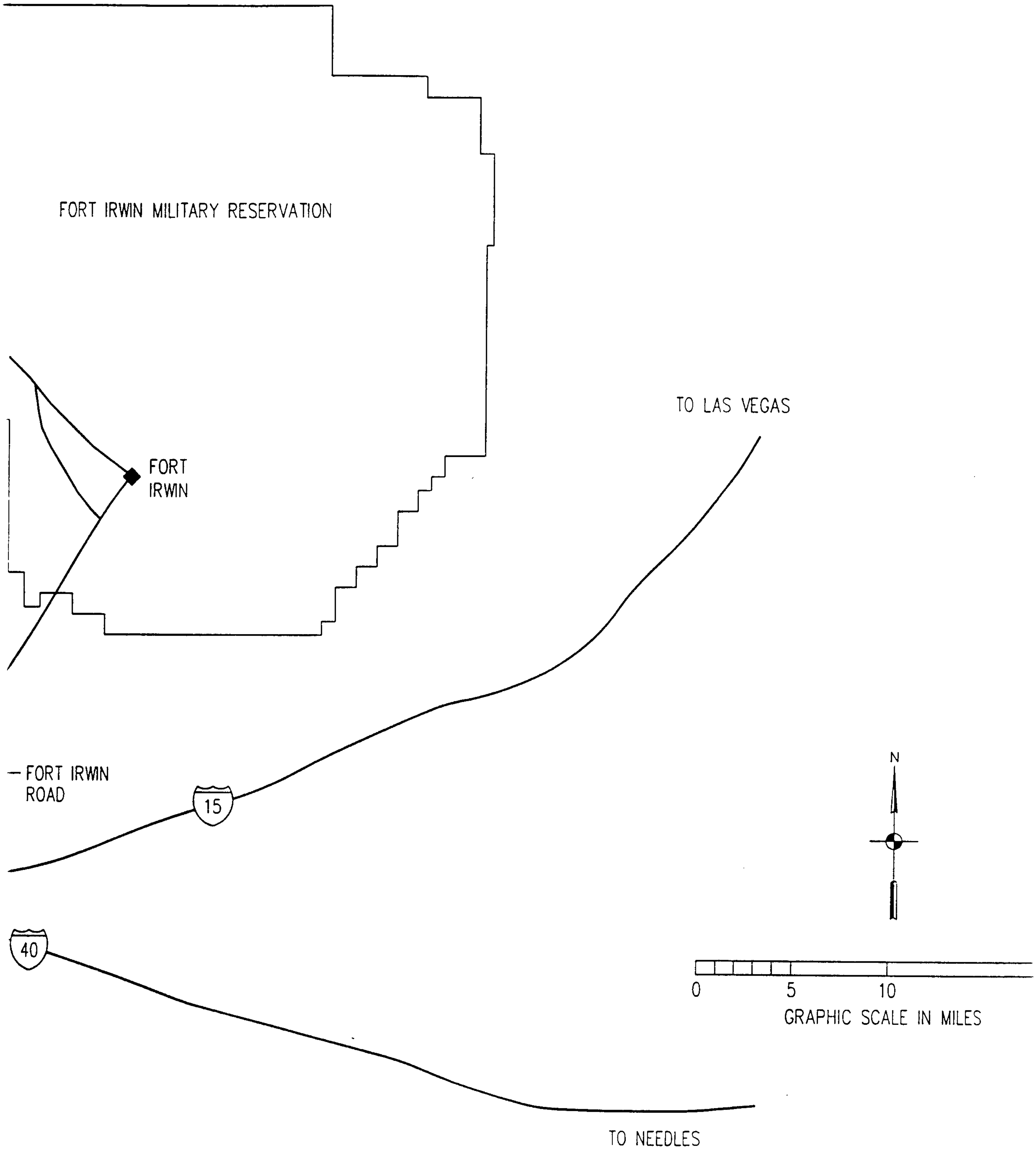


Figure 3-1
Fort Irwin Vicinity Map

2

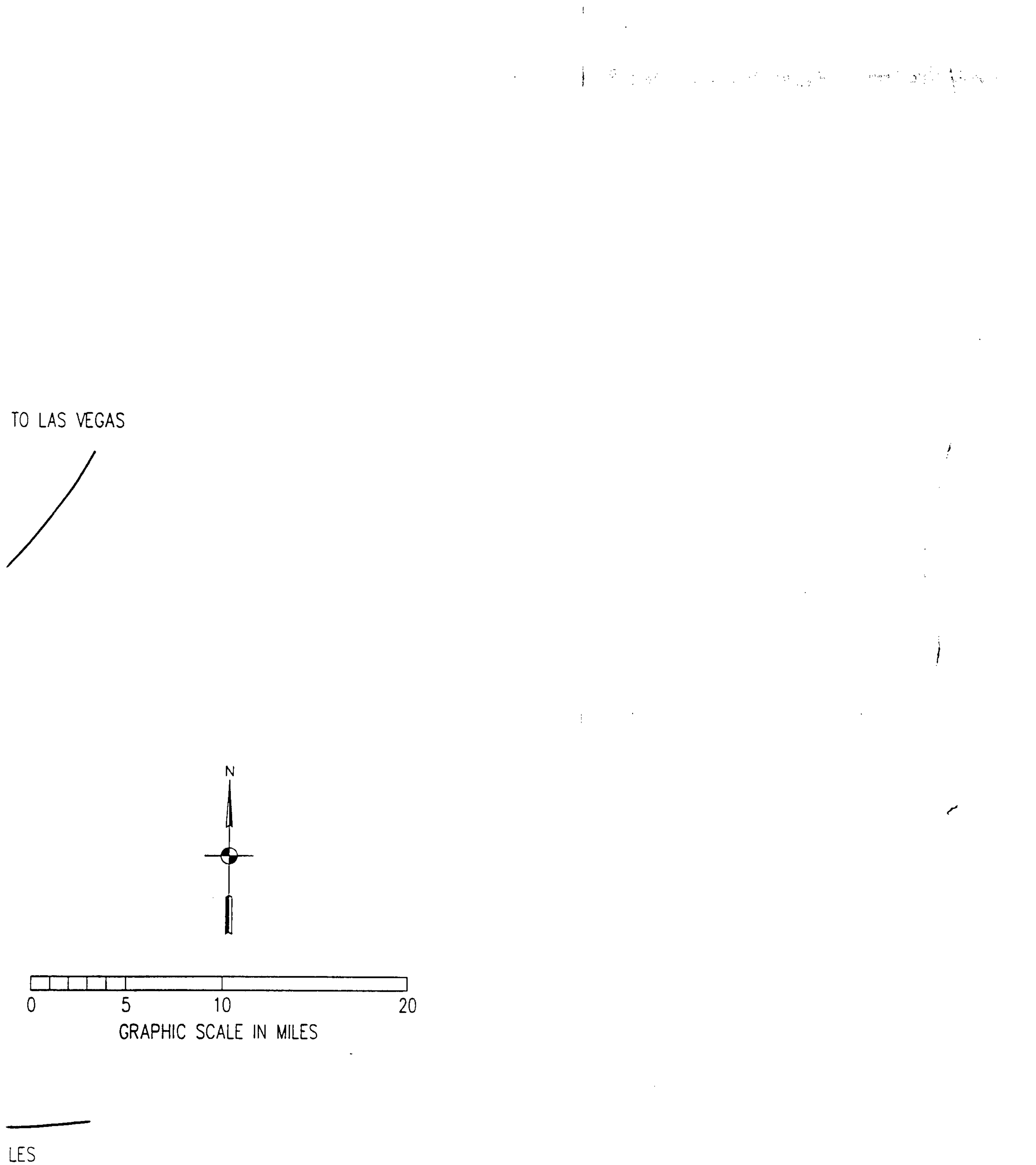


Figure 3-1
Fort Irwin Vicinity Map

3

Figure 3-2
Total Domestic Water Production - FY94, FY95 and FY96
Fort Irwin, California

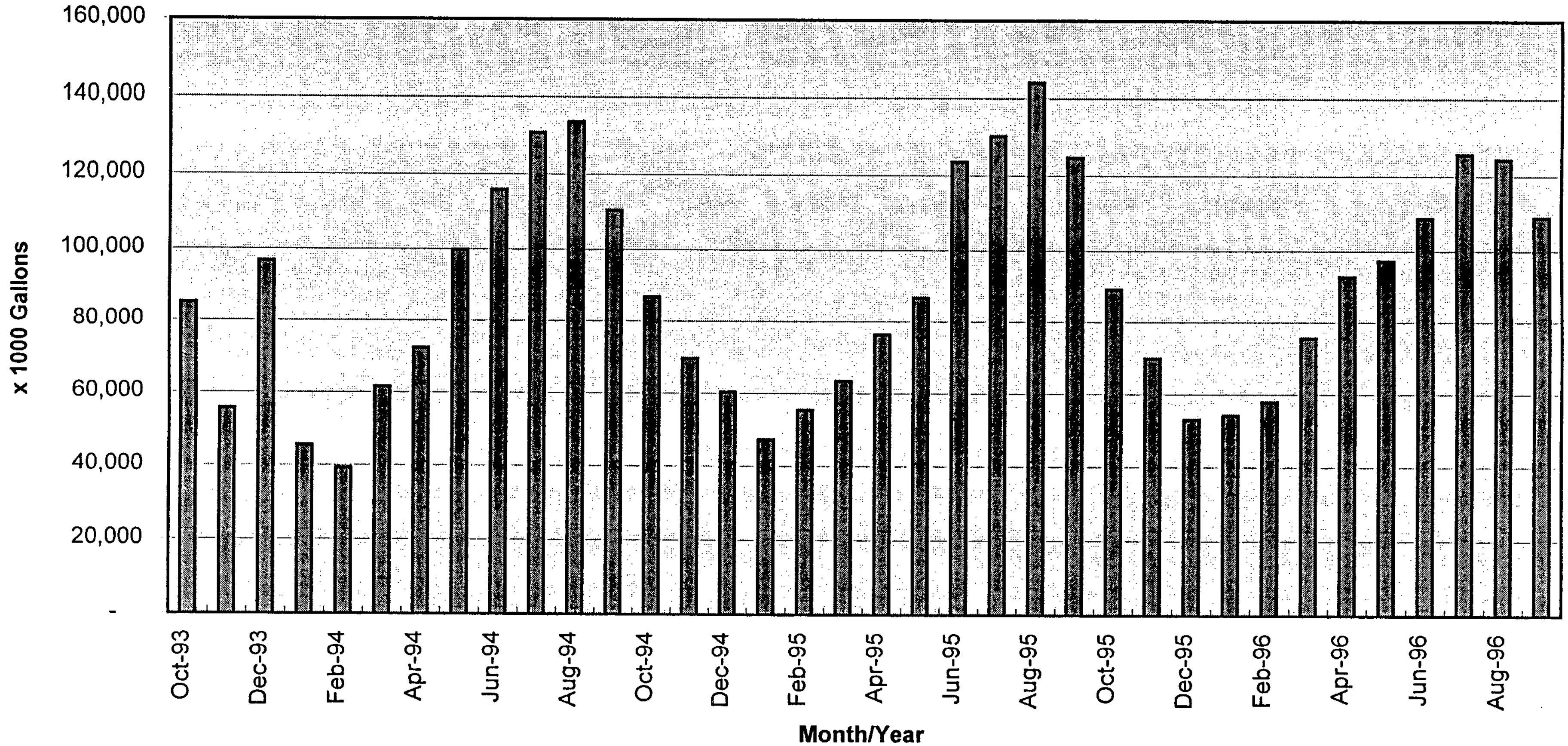
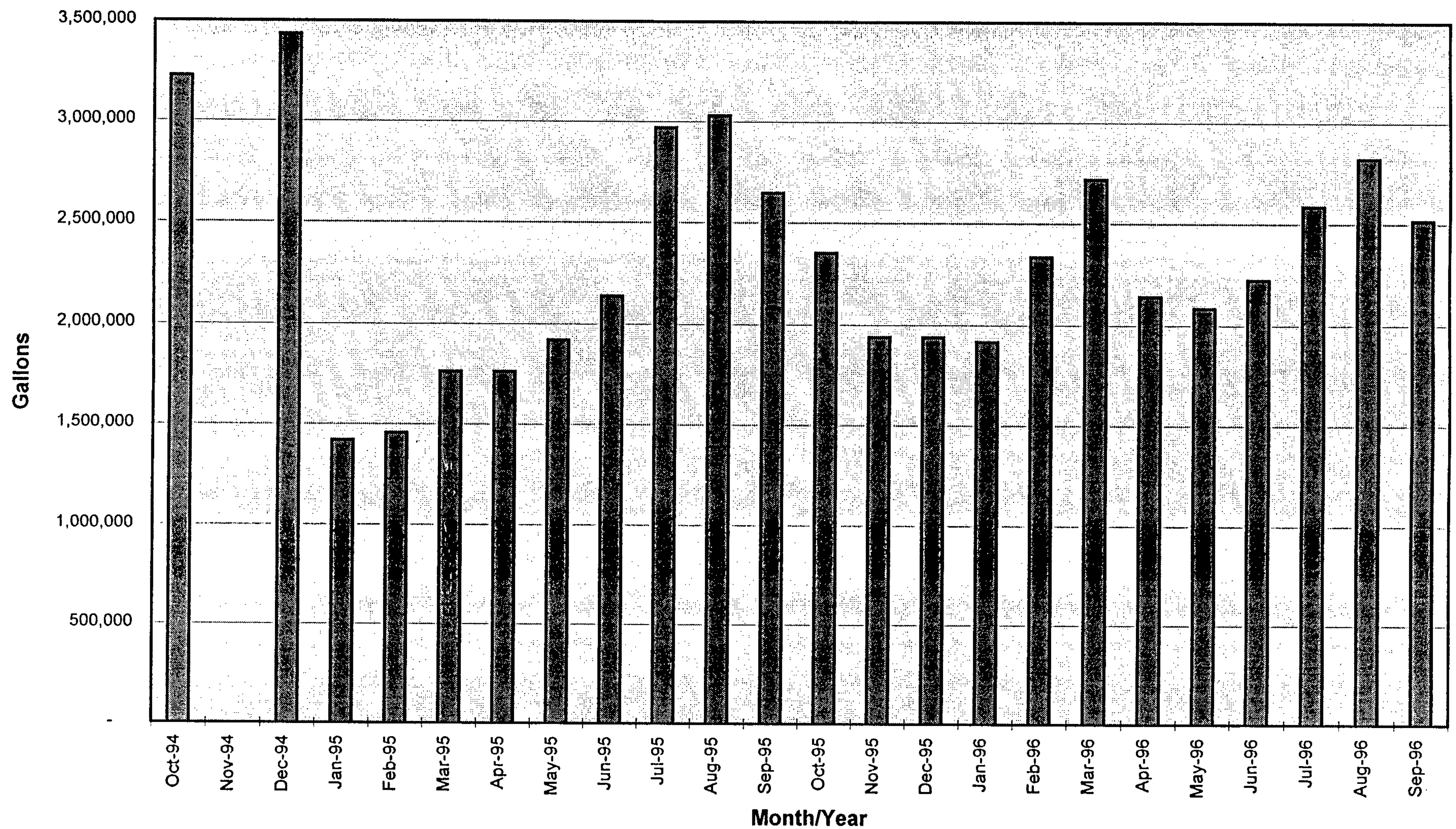
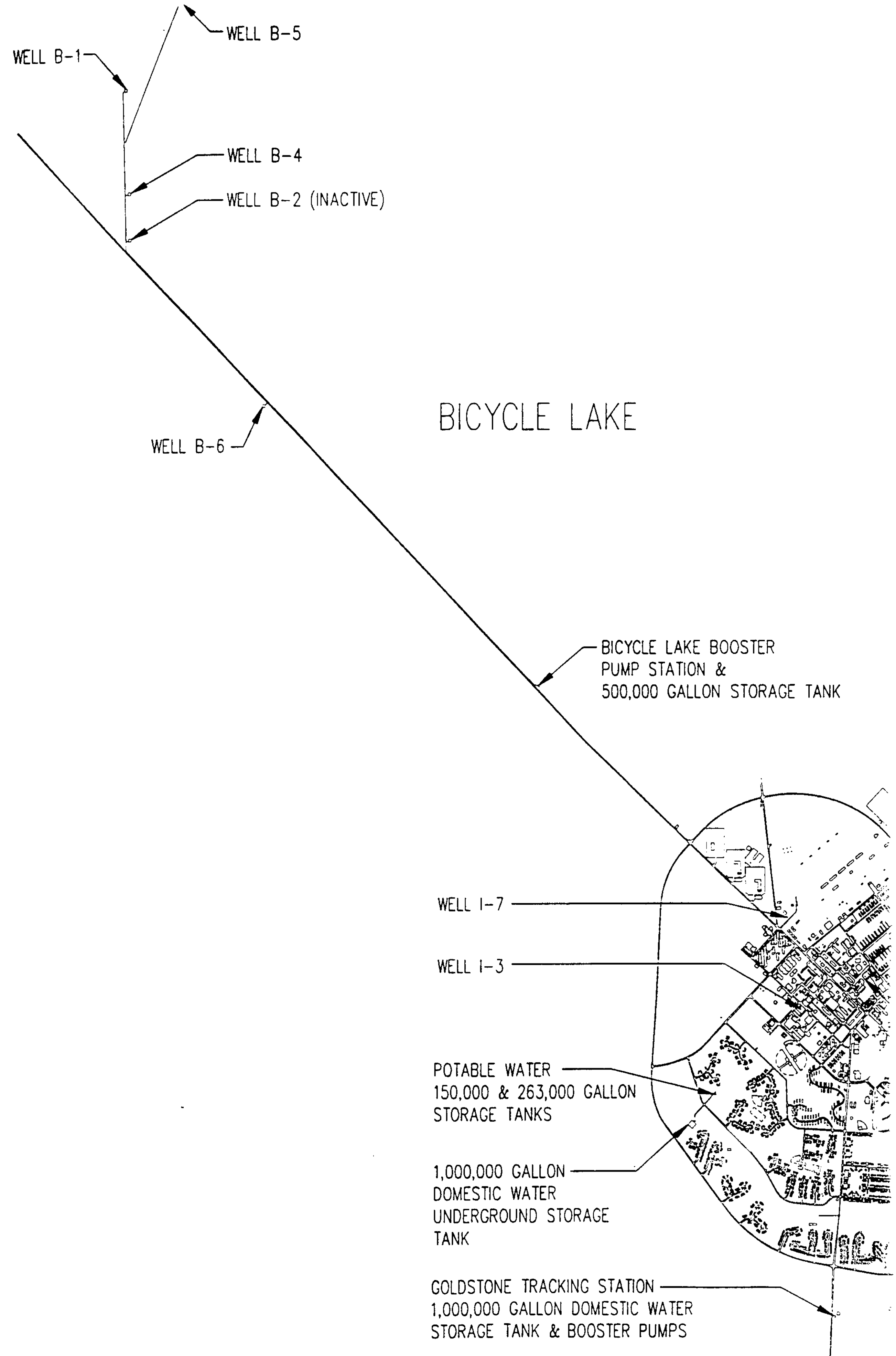


Figure 3-3
R. O. Plant Water Production - FY95 and FY96
Fort Irwin, California





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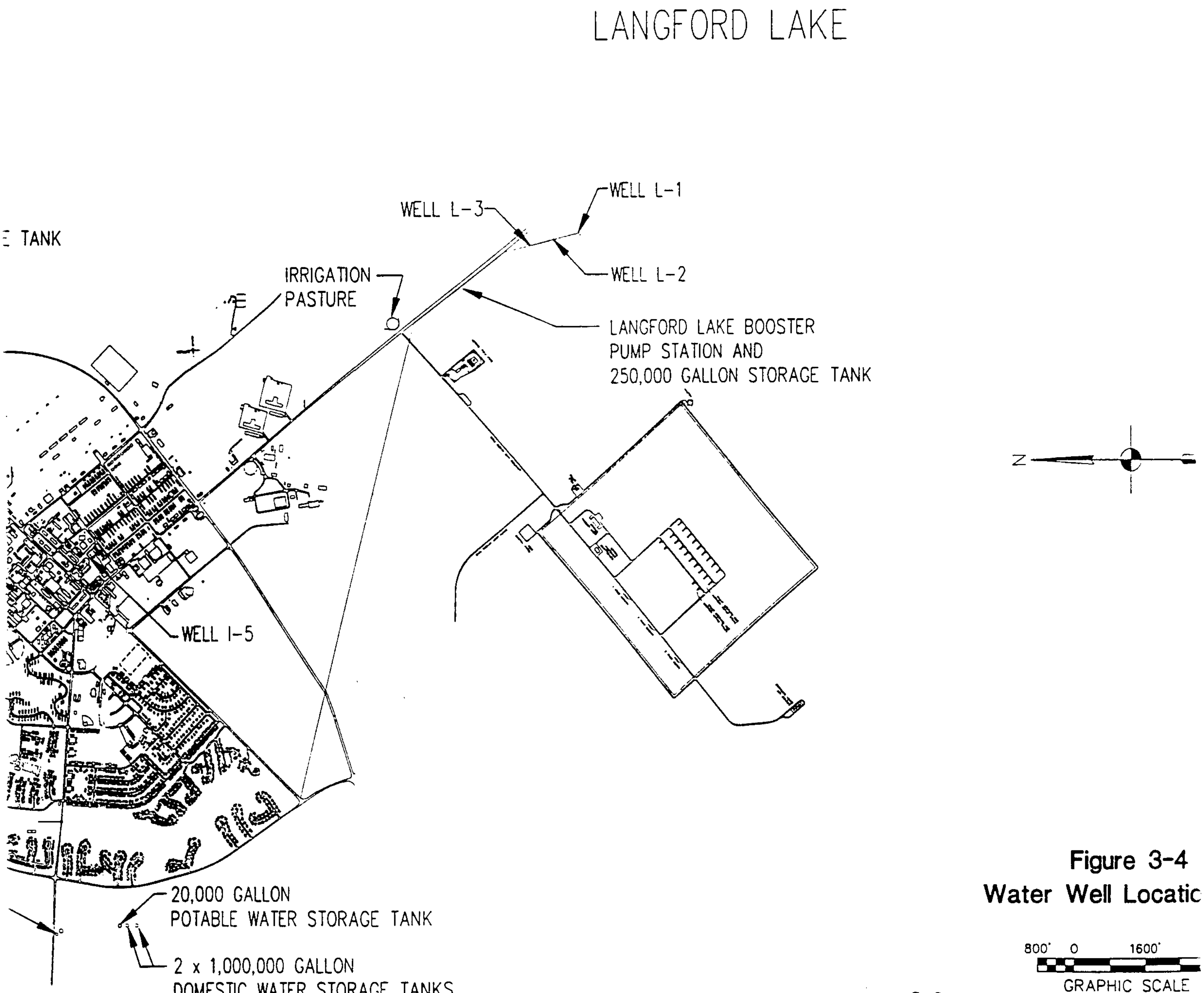


Figure 3-4
Water Well Locatic

2

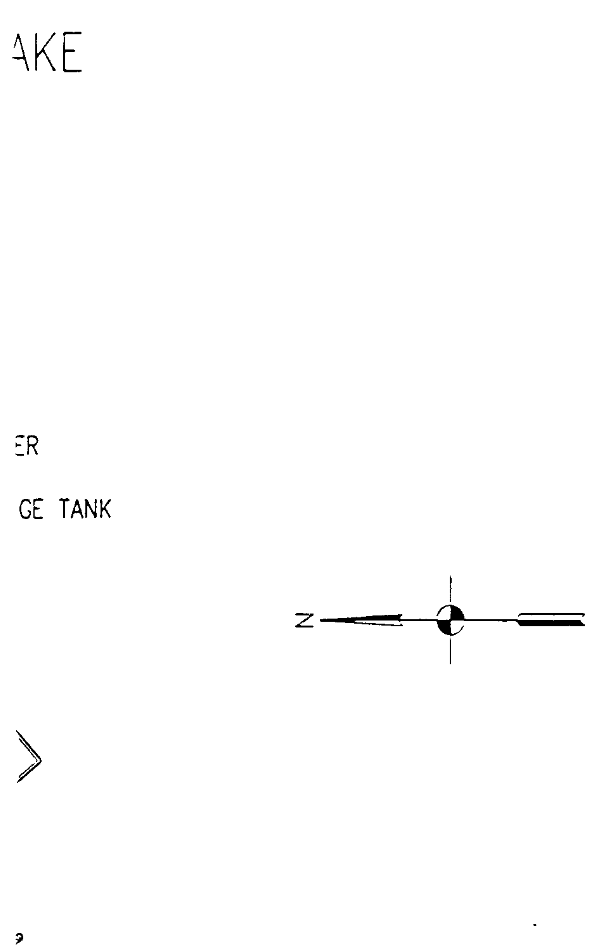
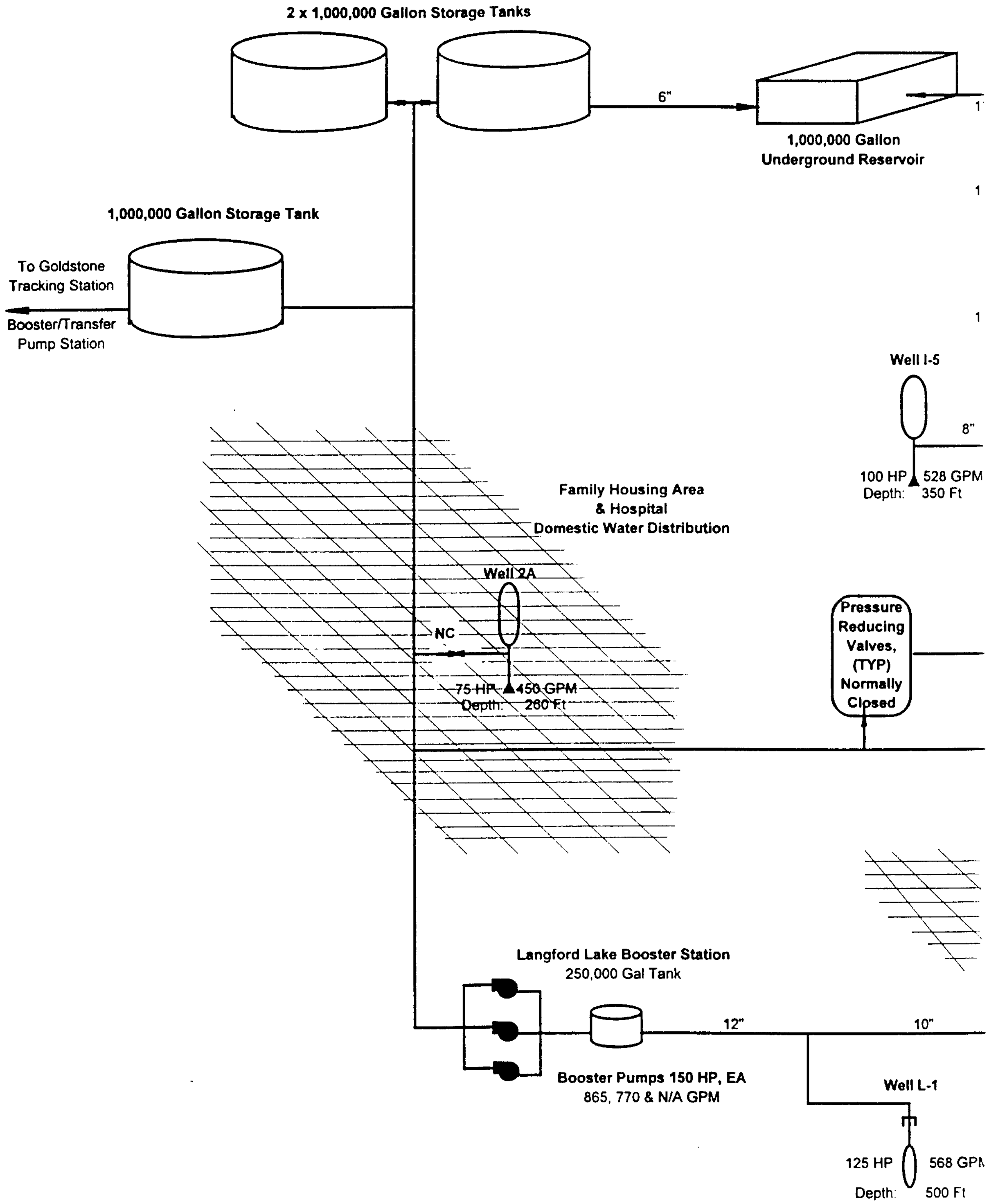


Figure 3-4
Water Well Location Map

800' 0 1600' 3200'
GRAPHIC SCALE

3



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F:\PROJ\1640321\ENGR\Figs-3.xls Figure 3-5

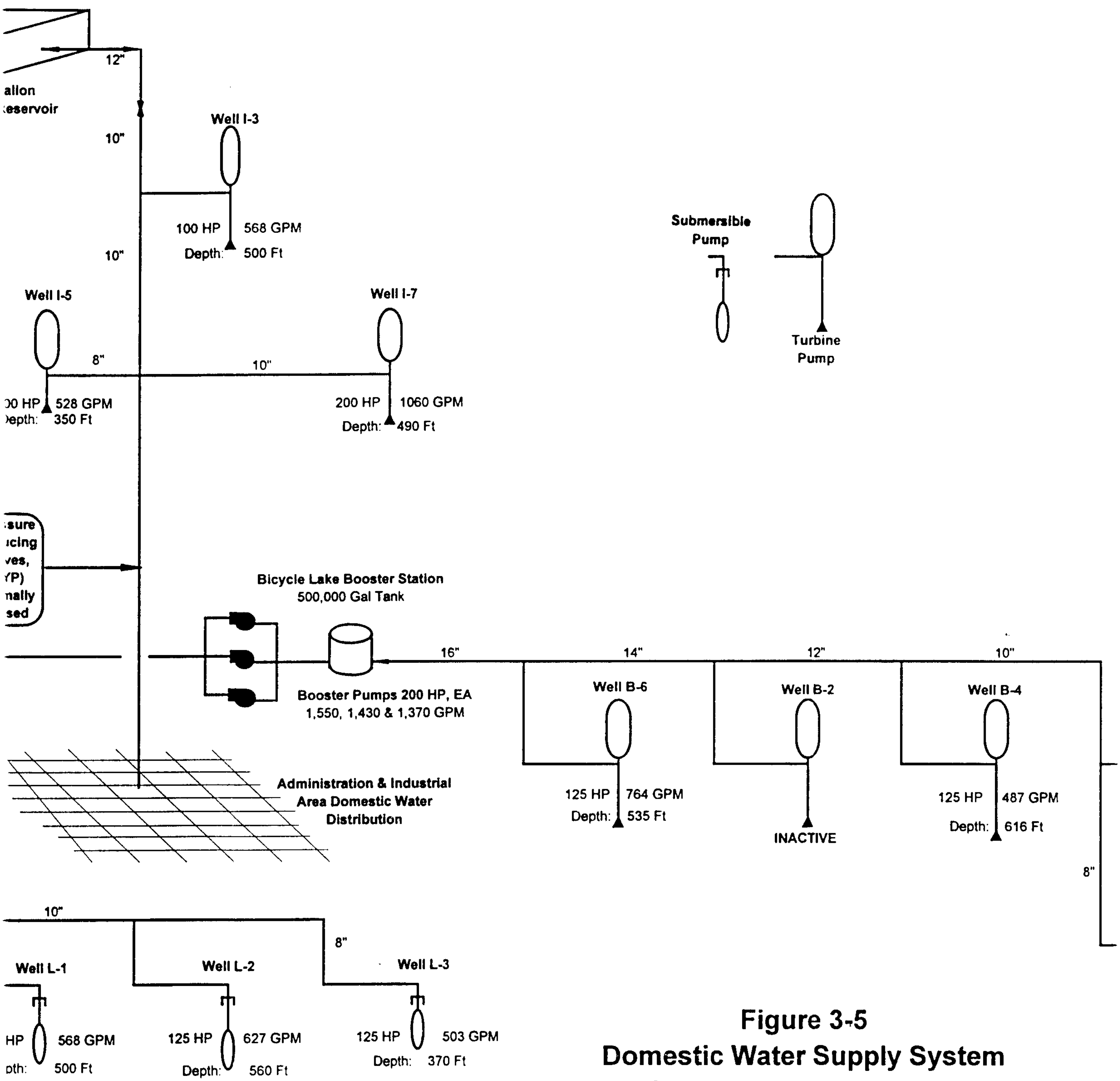
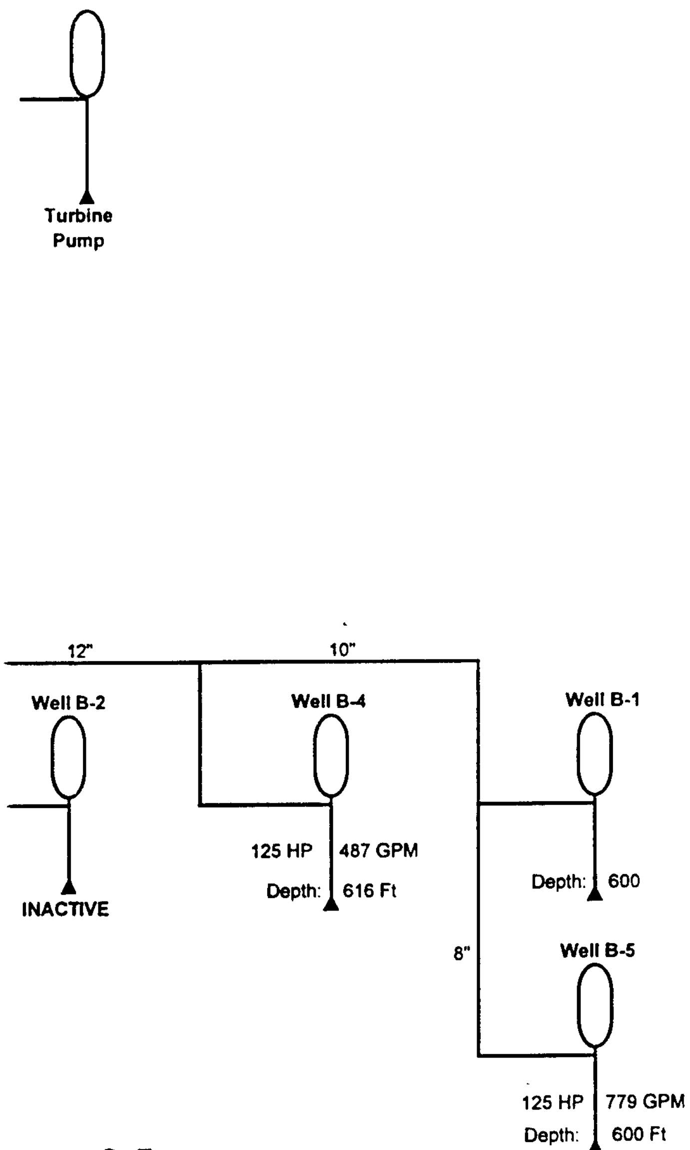


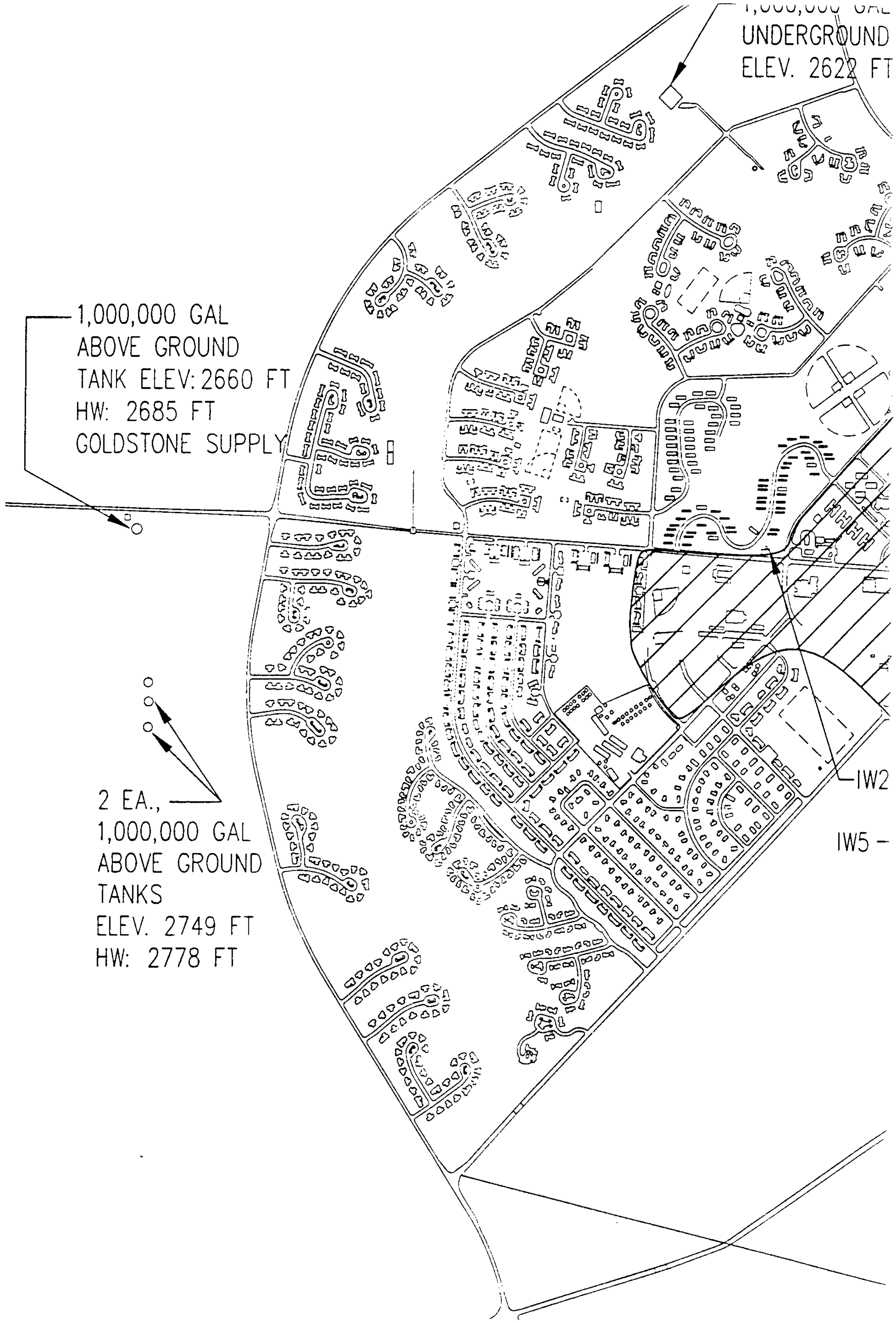
Figure 3-5
Domestic Water Supply System Simplified Flow Diagram

2



gure 3-5
ater Supply System
d Flow Diagram

3



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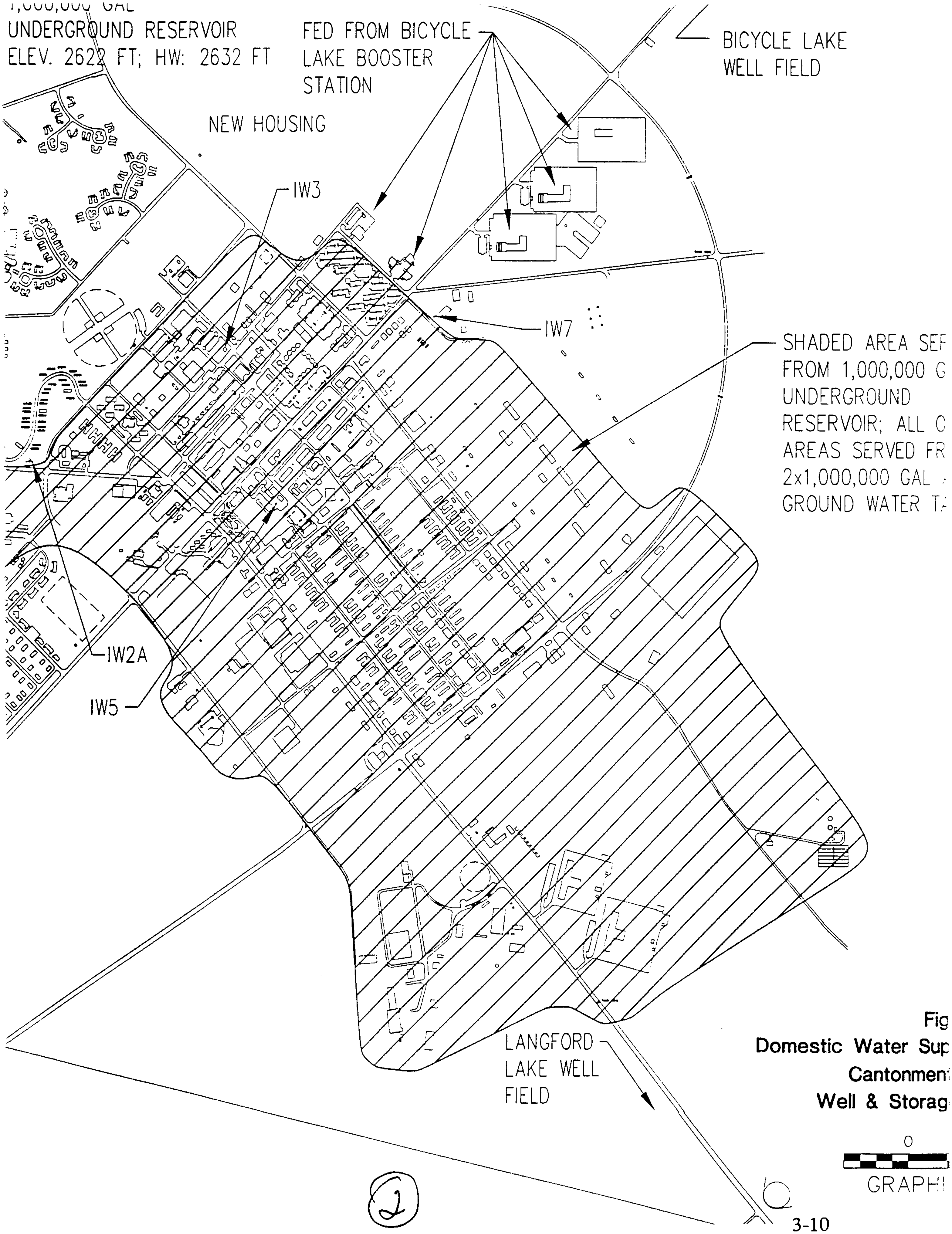
1


1,000,000 GAL
UNDERGROUND RESERVOIR
ELEV. 2622 FT; HW: 2632 FT
FED FROM BICYCLE LAKE BOOSTER STATION
BICYCLE LAKE WELL FIELD
NEW HOUSING
IW3
IW7
SHADED AREA SEF
FROM 1,000,000 G
UNDERGROUND
RESERVOIR; ALL O
AREAS SERVED FR
2x1,000,000 GAL
GROUND WATER T
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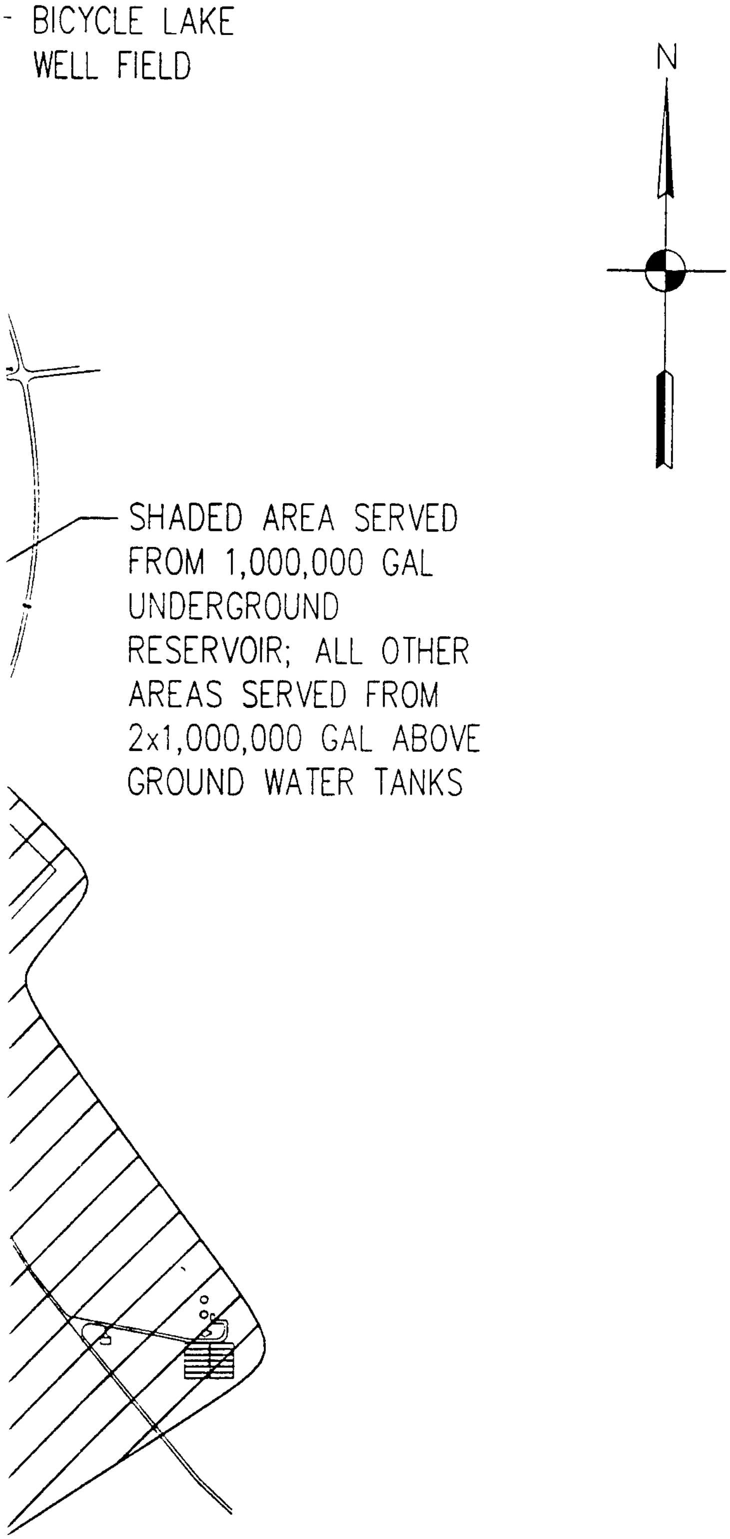
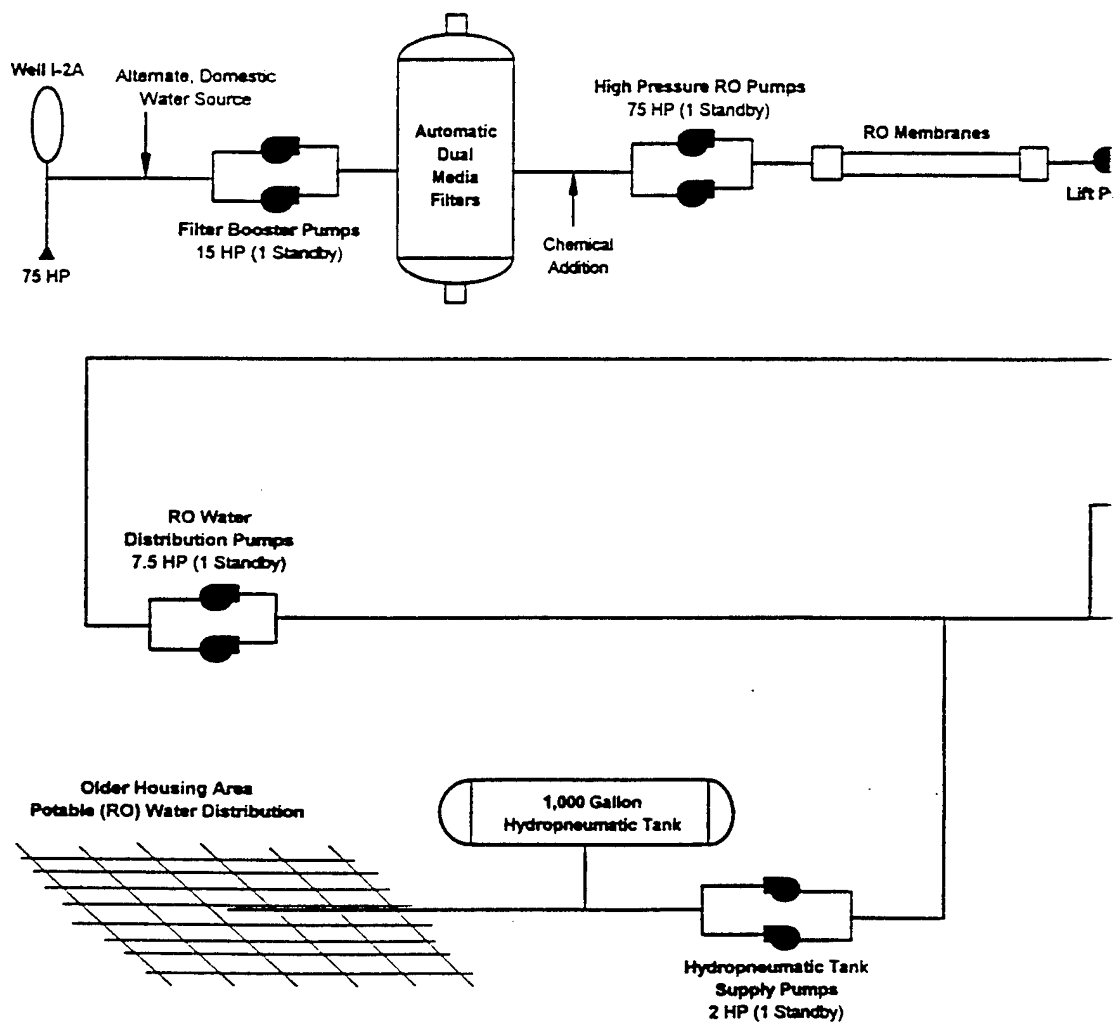


Figure 3-6
Domestic Water Supply & Distribution System
Cantonment Service Areas,
Well & Storage Tank Locations

0 800' 1600'
GRAPHIC SCALE

3



Well I-2A
75 HP
Alternate, Domestic Water Source
Filter Booster Pumps 15 HP (1 Standby)
Automatic Dual Media Filters
Chemical Addition
High Pressure RO Pumps 75 HP (1 Standby)
RO Membranes
RO Water Distribution Pumps 7.5 HP (1 Standby)
Older Housing Area Potable (RO) Water Distribution
1,000 Gallon Hydropneumatic Tank
Hydropneumatic Tank Supply Pumps 2 HP (1 Standby)

1

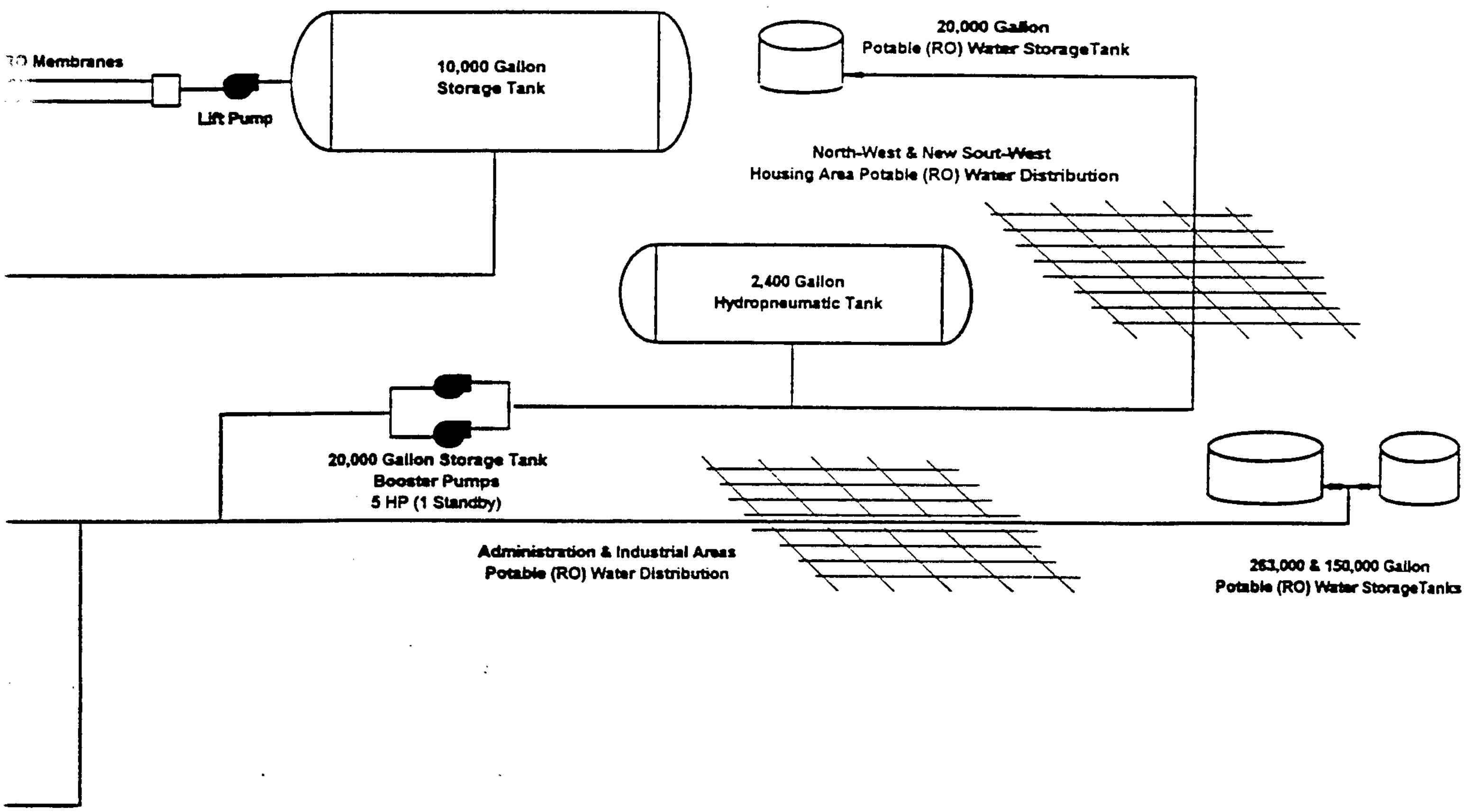


Figure 3-7
Reverse Osmosis Supply ar
System - Simplified Flov

(2)

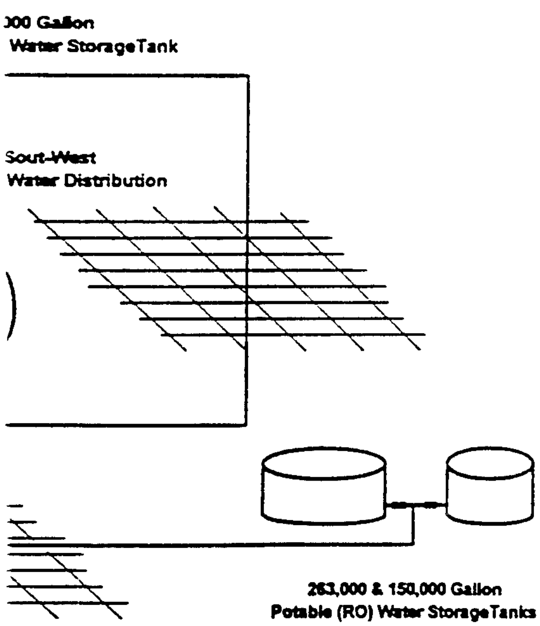
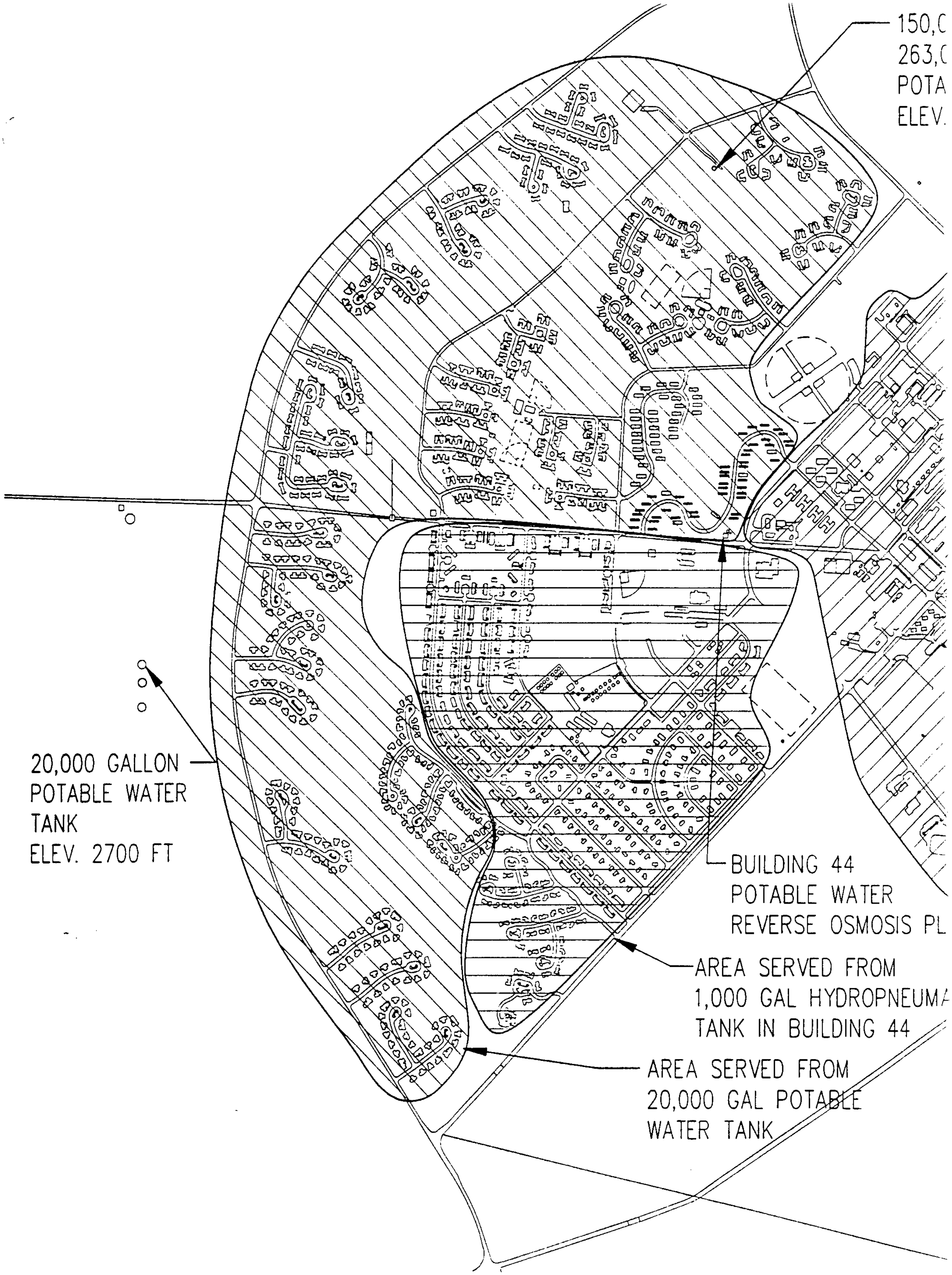


Figure 3-7
Reverse Osmosis Supply and Distribution System - Simplified Flow Diagram

(3)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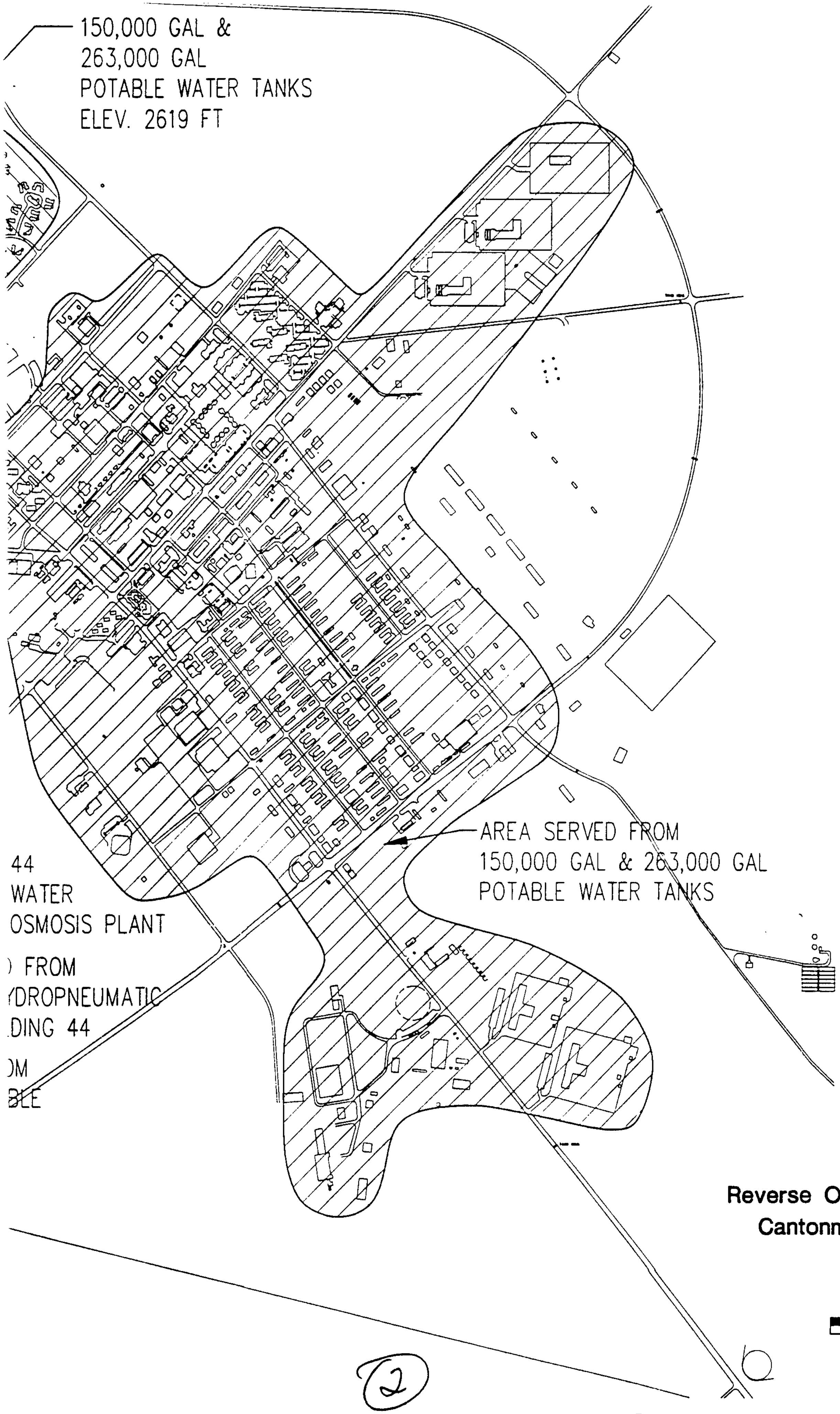

Figure 3-8
Reverse Osmosis Supply & Distri
Cantonment Service Areas, R(
Storage Tank Locatior

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GRAPHIC SCALE

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Figure 3-8
verse Osmosis Supply & Distribution System
Cantonment Service Areas, RO Plant and
Storage Tank Locations

0 800' 1600'
GRAPHIC SCALE

3

Table 3-1
Water Well Data Summary

Well Designation	Pump Type	Tested Capacity (GPM)*	Motor HP	NEMA Nominal Motor Efficiency	Cased Depth (Feet)	Well Diameter (Inches)	kWh Metering	Capacitor Size (kVAR)
B-1	Turbine	628	125	0.930	600	14.0	-	10
B-4	Turbine	487	125	N/A	616	14.0	-	30
B-5	Turbine	779	125	0.945	600	14.0	-	10
B-6	Turbine	764**	125	0.945	535	14.0	-	10
L-1	Submersible	568	125	N/A	500	14.0	Yes	-
L-2	Submersible	627	125	N/A	560	14.0	Yes	-
L-3	Submersible	503	125	N/A	370	14.0	Yes	-
I-2A	Turbine	450	75	N/A	260	14.0	-	-
I-3	Turbine	568	100	0.954	500	14.0	-	-
I-5	Turbine	528	100	0.952	350	14.0	-	-
I-7	Turbine	1060	200	N/A	490	14.0	-	-

* Flows as measured during December 1995 pump efficiency tests by Dyncorp, unless noted otherwise.

** Flow observed during December 1996 water conservation survey.

Table 3-2
Booster Pump Data Summary

Pump Designation	Measured Capacity (GPM)*	Motor HP	NEMA Nominal Motor Efficiency	kW/kWh Metering
BB-1	1550	200	0.941	No
BB-2	1430	200	0.941	No
BB-3	1370	200	0.941	No
LB-1	865	150	N/A	Yes
LB-2	770	150	0.962	Yes
LB-3	Out of Service	150	0.962	Yes
Goldstone	150	75	0.895	Yes

* Flow measurements obtained during December 1996 survey.

N/A Denotes data not available from nameplate

4.0 Evaluation of Water Distribution Systems

4.1 Life Cycle Cost Analysis Assumptions

4.1.1 Economic Assumptions

Economic analysis based on present value techniques were performed on all potential domestic and reverse osmosis distribution system water conservation opportunities and repairs using the economic analysis form and procedures outlined in "Energy Conservation Investment Program (ECIP) Guidance" dated 6 September 1996. The following assumptions and methods were used to develop standard input for economic analysis of all projects:

a. Investment costs include the following: Construction costs; contingency estimated at 10% of construction costs; supervision, inspection and overhead (SIOH) at 5.5% of construction costs; and design at 6% of construction costs.

b. The economic analysis was performed based on current (second quarter FY97) cost.

c. Discount factors and uniform present value factors used in computing present values are obtained from the current annual supplement to NIST Handbook 135, "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis 1997," NISTIR 85-3273-11, dated July 1996. The discount rate set for 1997 by the Department of Energy is equivalent to a market rate of 6.6%. Allowing for a projected rate of general price inflation of 3.1% yields a 3.4% "real" discount rate. Uniform present value factors (designated FEMP UPV*) using the 3.4% discount rate and adjusted for average fuel price escalation in the industrial sector for Census Region 4 are used in the analysis below.

d. The present value of recurring non-energy benefits and costs was obtained using a 0% differential rate and a 3.4% discount rate.

4.1.2 Energy Cost Assumptions

Electric power is provided to Fort Irwin by Southern California Edison Company (SCE) under Rate Schedule TOU-8-CR-1, which includes time-of-use billing together with an incremental sales rate (ISR) rider. The ISR agreement provides for a base level of kWh consumption and kW demand billed at a fixed monthly amount, with consumption and demand above the base levels billed at the incremental rates, which are revised monthly based on SCE's avoided cost of energy. Fort Irwin is billed for the base levels of consumption and demand whether or not actually attained.

The SCE TOU-8 rate schedule provides for six distinct periods of usage, each with its own applicable rates. During the summer months, June through September, there are on-peak, mid-peak and off-peak periods. During the remaining eight months, there are mid-peak, off-peak and super off-peak periods. A demand charge is assessed during the summer months for the maximum demand that occurs during the on-peak (1200 to 1800 weekdays) and mid-peak (0800 to 1200 and 1800 to

2300 weekdays) periods. A non-time-related demand charge is assessed for the maximum demand obtained each month, regardless of the time period in which it occurs.

The incremental rate agreement between Fort Irwin and SCE as outlined above is in force through 1997, after which it may be discontinued. During the 1999 to 2000 period, significant changes in the method that Fort Irwin procures electricity will occur, with the advent of electric utility deregulation and the unbundling of electricity generation, transmission and distribution in California.

Due to the uncertainty associated with Fort Irwin's electricity rates in the future and the difficulty in accounting for monthly changes in incremental rates, the marginal energy savings rates assumed in this study are the current SCE base rates. A summary of the electricity consumption and demand rates used in the savings analysis follows:

Rate Period	Summer On-Peak	Summer Mid-Peak	Summer Off-Peak	Winter Mid-Peak	Winter Off-Peak	Winter Super Off-Peak
Dollars/ kWh	0.09422	0.05847	0.03758	0.07071	0.03874	0.03874
Dollars/ kW/Month*	17.95	2.70	0.00	0.00	0.00	0.00

* In addition, a non-time-related charge of $6.60 per kW is assessed for the maximum demand each month, regardless of the time of occurrence.

Therefore, for a project that generates energy savings throughout the year in proportion to the historical energy breakdown between rate periods, the projected annual savings rates are:

Energy Charge: $0.05393 per kWh ($15.80 per million BTUs)

Demand Charge: $161.80 per kW [($17.95 + $2.70) x 4 + $6.60 x 12]

4.1.3 Water Cost Assumptions

Determination of an average cost of domestic water production and distribution at Fort Irwin includes the cost of electricity to power all the well pumps and booster pumps in the system as well as the manpower and materials necessary to operate and maintain the supply and distribution system. Based on FY96 equipment operating histories, current electricity demand and consumption rates, and current manning levels and compensation rates, the estimated average cost of domestic water is $0.9704 per 100 cubic feet, or $1.2972 per 1000 gallons. Refer to Appendix D for backup data and calculations.

A similar analysis was performed to determine the average cost of reverse osmosis water production and distribution. Electricity to power the reverse osmosis plant and dedicated well pump is the major cost component, since the RO plant operates mostly unattended. The estimated average cost of reverse osmosis water is $5.1758 per 100 cubic feet, or $6.9186 per 1000 gallons. Refer to Appendix D for backup data and calculations.

For the purposes of calculating life cycle cost savings that result from water conservation projects, the marginal cost of water is used. Unlike the average cost of water production and distribution, the marginal cost does not include expenses for such items as maintenance materials, safety equipment and in-house labor that are not impacted by reduced water production. An allowance for the avoided cost of outside labor equal to 25 percent of the average labor cost is included as a marginal O&M cost savings.

The marginal costs of water production and distribution is summarized as follows:

Water System	Cost Per 100 Cubic Feet	Cost Per 1000 Gallons
Domestic	\$0.4064	\$0.5433
Reverse Osmosis	\$2.9967	\$4.0058

4.1.4 Construction Cost Estimate Methodology

Construction cost estimates for water conservation opportunities are prepared to the level of accuracy required to assess project economic viability and, therefore, may be considered as budget level cost estimates. Labor and material costs are based predominately on the 1997 Means cost estimating guides with adjustments for geographic location and difficulty of retrofit work, as appropriate. Whenever feasible, budget quotes from equipment manufacturers have been obtained to improve accuracy.

Factors added to the subtotal of labor and materials costs include:

- California State Sales Tax at 7.75% (added to materials cost only)
- Contractor Overhead and Profit at 25%
- Performance Bond at 1.5%
- Estimating Contingency at 10%

The resulting probable construction costs are used subsequently in life cycle cost analysis.

4.2 Domestic Water Supply and Distribution System

4.2.1 Leak Repairs

An instrumented leak detection survey covering both the domestic and reverse osmosis water distribution systems in the Cantonment Area was performed during the period of 9 through 13 December 1996. Precise locations of all of the located leaks were reported to the Fort Irwin DPW Water Department prior to departure of the leak survey team.

A total of 14 leaks were identified in the domestic water distribution system including two leaks in distribution mains, one valve leak, seven hydrant leaks and four leaks of other origin. Total water loss through these leaks is estimated to be 100,440 gallons per day. This quantity represents only about 5 percent of the average winter daily domestic water production at Fort Irwin, which compares very favorably to distribution system water losses in other Army installations.

For a summary of leak locations and estimated rates of water loss, refer to Table 4-1. The complete Leak Detection Survey Report appears in Appendix B.

4.2.2 Phased Pipe Replacements

The last major water distribution system replacement project occurred in 1967. As sections of the domestic water distribution piping require replacement, schedule 80 PVC has been the preferred material by Fort Irwin DPW. A phased plan to replace aging sections of domestic water distribution mains in the industrial area has been developed. Table 4-1 summarizes the phases of the proposed project by location, priority based on the age and condition of existing piping and estimated construction cost. Figure 4-1 shows the physical boundaries of the proposed phased replacement areas.

Refer to Appendix F for a summary of sizes and ages of existing domestic water mains plus detailed construction cost estimates for their replacement with PVC piping.

4.2.3 Reclamation of Flushing and Pressure Testing Water

All active fire hydrants are flowed annually in order to perform residual pressure tests; and a number of hydrants are flushed annually to clear lines of accumulated silt. Each flush is performed with at least a 2-1/2-inch diameter port opened 100 percent for a duration of 20 minutes; and each fire hydrant residual pressure test requires no more than a few minutes of flow. Residual pressure testing and system flush water is presently allowed to flow directly to the storm drainage system. Since there are 299 active fire hydrants on Fort Irwin, annual water losses from these activities are considerable.

It is proposed to collect flush water and fire hydrant residual pressure test water in water trucks for use in irrigation and dust control. Water is presently dispensed from water trucks filled from the domestic water distribution system for these purposes, thus, this collected water represents true savings.

Domestic water system flush water can be flowed through hoses directly into top loading manholes of water trucks. Sand and silt deposited in the water truck tanks can be removed with much less flushing water than is flowed from the hydrants.

To collect fire hydrant residual pressure testing water, it will be necessary to modify the hydrant testing procedure to flow the hydrant into a water truck. It is recommended that a pitot tube and pressure gauge be fitted into a custom pipe spool attached to the top-loading fitting on the water truck. Fabrication of a total of six custom pipe spools will allow for residual tests where multiple hydrants must be flowed.

The estimated water savings by collecting hydrant residual testing flows and domestic water system flushing flows is 1,582,000 gallons per year. With an initial investment in six custom pipe spools of $2,091, this project generates annual savings of $260, a simple payback period of 8.06 years and a savings-to-investment ratio of 2.00. Refer to Appendix E for the detailed analysis and calculations.

4.2.4 Minimization of Well Water Pumping Costs

The well pumps at the three ground water basins supplying water to Fort Irwin currently operate intermittently throughout the day to maintain adequate levels in the four 1,000,000 gallon storage tanks serving the domestic water system. Scheduling of pumping during off-peak electricity rate periods is partially successful during the winter months due to the lower demand. However, during the high-demand summer months, existing storage is not sufficient to preclude pumping during on-peak electricity rate periods. Adding another storage tank and revising well pumping schedules to avoid the costly on-peak period will lower both electricity usage and demand charges. Although overall electricity usage will not be reduced by shifting well operations to mid-peak and off-peak periods, the overall cost of energy for pumping water will be reduced since it will be consumed during lower-cost rate periods.

A new water tank sized at 750,000 gallons will provide enough storage to eliminate all well pump operations during the summer on-peak rate period from 1200 to 1800 hours. The proposed location of the new tank is adjacent to the existing Ammunition Storage Area, which will allow gravity feed to the Administration and Industrial Areas located at lower elevations.

The estimated electricity usage shifted from on-peak and mid-peak to off peak periods is 703,000 kWh per year; and the estimated electricity demand shifted to off peak periods is 787 kW per month. With an estimated investment cost of $827,665, this project generates annual savings of $114,262, a simple payback period of 7.24 years and a savings-to-investment ratio of 2.08. Refer to Appendix E for detailed savings calculations and the construction cost estimate.

4.2.5 Repair/Modifications for One Million Gallon Underground Tank

The one million gallon underground water tank, the original water supply tank for Fort Irwin, has reportedly started to leak because the tar seals between concrete slabs have deteriorated and are melting away due to increased water temperature. The increased temperature is due to the recent installation of water-source heat pumps to serve the nearby 220-unit family housing expansion. The heat pumps utilize the water tank water as a heat sink. This arrangement is not unusual. However, the Fort Irwin water supply temperature exceeds that of most other areas where wells are the water source. Water pumped from wells serving Fort Irwin provide about 71 degrees F water whereas most wells provide water temperatures at least 20 degrees cooler.

In order to correct the situation and to provide proper cooling and heating to the 220-unit family housing, a project to reseal and line the reservoir and to construct a water cooling tower to serve the family housing area heat pump system was evaluated. The option of replacing the leaking reservoir with a new ground level tank was considered but rejected due to its excessive cost.

The cooling tower system will utilize more energy to cool heat pump condenser water than the current water tank system, and will require maintenance. However, cold water cannot be supplied above 80 degrees F and the family housing development requires heating and cooling. The proposed system would prevent the further leakage of domestic water and provide an operable heating and cooling system, as well as cooler water.

The investment required for this project is estimated at about $437,000. After accounting for the additional energy consumption by cooling tower fans plus additional water treatment costs and blowdown and drift water losses, this WCO does not generate sufficient water savings to justify the initial investment in a new cooling tower. Refer to Appendix E for detailed calculations and the construction cost estimate.

4.2.6 Water Conservation Projects Planned By Fort Irwin

A number of projects that will reduce water use at Fort Irwin by a significant amount are in the planning and design stages, including:

- Change in landscaping policy from plantings that require constant watering to those that are indigenous a high desert climate
- Rebuilding of vehicle wash racks to allow recycling of wash water
- Efficiency improvements at the reverse osmosis plant
- Use of wastewater treatment (tertiary) effluent to irrigate playing fields, parks and other common use turf-covered areas

Landscaping Policy

Without question, the single most effective change at Fort Irwin to reduce water consumption is the replacement of non-desert landscaping with plantings that are indigenous to the high desert. It is estimated that an average of 800,000 gallons per day is being used to irrigate lawns and other plantings. Once the program of "desertification" of Fort Irwin is completed, it is not unreasonable to expect a minimum 90 percent reduction in irrigation water usage, or 720,000 gallons per day on average.

Vehicle Wash Racks

At a number of existing vehicle wash racks at Fort Irwin, both maintenance cleaning and exterior washing operations are performed, thus generating wastewater that contains both petroleum-based lubricating (POL) products and detergents. Though difficult to treat, this wastewater is discharged into the sanitary sewer system. In addition, a large percentage of the wash water drains onto surrounding unpaved areas.

Projects are planned to provide complete wastewater treatment and recycling for all vehicle wash racks at Fort Irwin not presently so equipped. Treatment will include API oil/water separators,

intermittent sand filters, bag filters and liquid-phase activated carbon units to remove glycol contaminants. Additional hardstand will be constructed to limit wash water drainage onto unpaved areas. Total washrack wastewater discharges to the sanitary sewer system were estimated at 11,000,000 gallons per month by a September 1994 HAZMAT data report, "Oil/Water Separator Information." If all wastewater is recycled, less an allowance of 10 percent for makeup water, then annual domestic water savings is estimated at 118,800,000 gallons, or an average daily water savings of 325,000 gallons.

Reverse Osmosis Plant

Plans are in place to overhaul the reverse osmosis plant with new and improved reverse osmosis membranes and a packaged King-Lee treatment system, thus improving the plant's efficiency from the present 46 percent to greater than 70 percent. Total FY96 raw water supply to the plant was 62.6 million gallons; and demineralized water production for FY96 was 28.8 million gallons. Thus, a 70-percent-efficient plant would require a raw water supply of 41.1 million gallons, or 21.5 million gallons less raw water to maintain FY96 annual RO water production levels.

If the current hours of plant operation are maintained, the increased plant efficiency will result in an estimated 15.0 million gallons per year of additional RO water production, thus permitting the addition of new service connections at Fort Irwin.

Irrigation With Wastewater Treatment Effluent

A study is currently being conducted for Fort Irwin examining upgrades to the wastewater treatment plant to include tertiary treatment and ultraviolet treatment. Effluent from the upgraded plant may be used to irrigate existing and new soccer fields, baseball fields, and other common use areas that are presently irrigated with domestic water. Installation of a new underground pipeline about two miles from the upgraded wastewater treatment plant to the cantonment area irrigation sites will be required to implement this water savings project.

4.3 Reverse Osmosis Water Distribution System

4.3.1 Leak Repairs

An instrumented leak detection survey of the reverse osmosis distribution system conducted during the period of 9 through 13 December 1996 yielded a total of three leaks generating an estimated water loss of 28,800 gallons per day. Two of the leaks, located in service lines and generating an estimated 21,600 gallons per day in losses, were repaired during the week of the survey. For a summary of leak locations and estimated water loss rates, refer to Table 4-1. The complete Leak Detection Survey Report appears in Appendix B.

4.3.2 Phased Pipe Replacements

Most of the reverse osmosis system distribution system mains in the industrial area have been replaced with PVC piping. However, most of the laterals to buildings are copper, which requires

the addition of zinc orthophosphate to protect the metallic pipe from corroding. Accordingly, it is recommended that all copper RO water laterals in the industrial area be replaced with PVC piping.

4.3.3 Reclamation of Flushing Water

The potable, or reverse osmosis, water system is composed of a combination of originally installed copper, galvanized and asbestos concrete (AC) piping; polyethylene (PE) pipe installed later and, more recently, polyvinyl chloride (PVC) piping. In the early 1980's, it was discovered that copper and galvanized piping were corroding and lime was leaching out of AC piping. Chemical treatment of the RO water was commenced, with sodium silicate and sulfuric acid added to control pH and zinc orthophosphate added to form a coating which fuses to interior pipe surfaces, masking them from continued corrosion.

In order to keep the protective coating on the interior surfaces of RO water distribution piping, it is necessary to maintain water flow. Most of the distribution system maintains enough flow due to consumption. However, several portions of the distribution system are at relative "dead-ends" where sufficient water to maintain the chemical coating is unavailable. Periodic flushes of metallic piping are performed from specific points to provide flow and allow the coating to fuse to the pipe walls. This flush water is presently allowed to flow to the storm drainage system.

Metallic piping serving the older family housing areas is being replaced with PVC piping along with building renovations. Therefore, the corrosion problem for distribution system piping will cease in these areas.

A WCO to collect RO distribution system flush water in water trucks for use in irrigation and dust control was evaluated. Water is presently dispensed from water trucks for these purposes, therefore, this collected water represents true savings.

Estimated annual volume of RO water lost through distribution system flushing is based on a 20-minute maximum period at 60 psig for 41 flush points every three months. Estimated volume of RO water lost per flushing cycle is 247,205 gallons; and estimated annual volume of RO water lost is 988,819 gallons. Allowing 20 hours per month for an additional water tank operator, the annual cost of additional O&M exceeds the annual cost of energy savings; therefore, this WCO is not recommended.

An alternate solution for reclaiming RO distribution system flush water is the provision of pump loops. However, the cost of the numerous pump loops required would far exceed the minimal water cost savings generated.

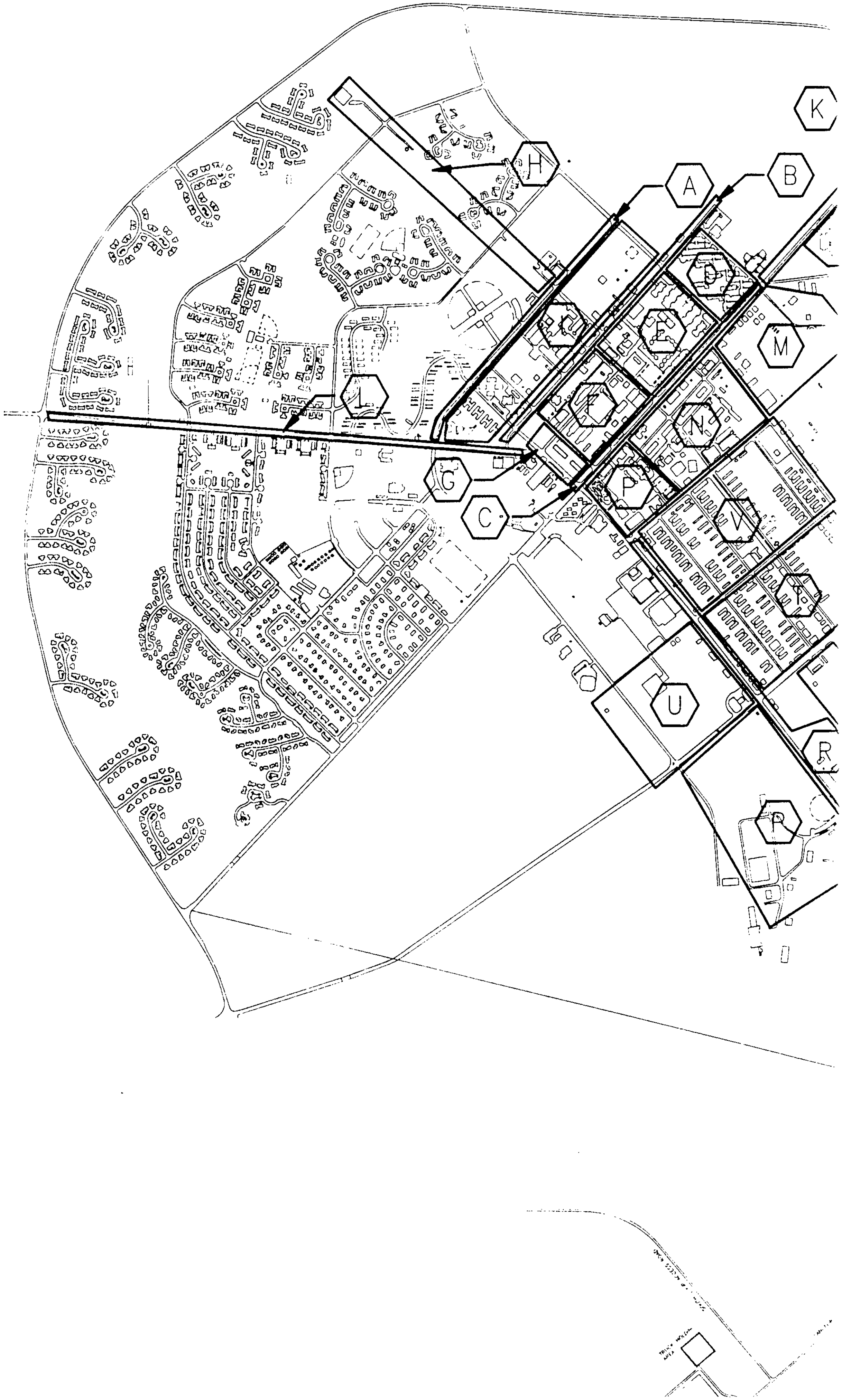
4.5 Desert Coyotes Versus Irrigation Sprinklers

It has been reported that numerous irrigation water leaks have been caused by coyotes attacking sprinkler heads and digging up plastic distribution piping for water. The piping, buried a few inches below grade, when damaged, allows water pressure to blow off damaged plastic fittings.

Watering troughs located, down range, well away from the cantonment area are provided for the animals in an attempt to keep them away from the built-up area. However, with the absence of human predators on federal property, and ready sources of food supplies from visiting troops, the coyotes frequently enter the cantonment area to search for both water and food. It has been estimated that upwards of 100 animals have their territory near the Irwin Basin.

Municipalities and irrigation supply companies in the high desert area were contacted regarding the problem of coyotes damaging irrigation systems. However, none of the offices contacted reported a problem similar to that occurring at Fort Irwin.

Based on discussions with irrigation system installers, two potential solutions are available in areas of irrigation systems susceptible to damage by coyotes: (a) retrofit plastic sprinkler heads and distribution piping with metal fittings and piping or (b) install metal guards over existing plastic sprinkler heads. It is recommended that future irrigation systems and replacement parts be specified with metal heads and risers with plastic piping buried at least 12-inches deep.



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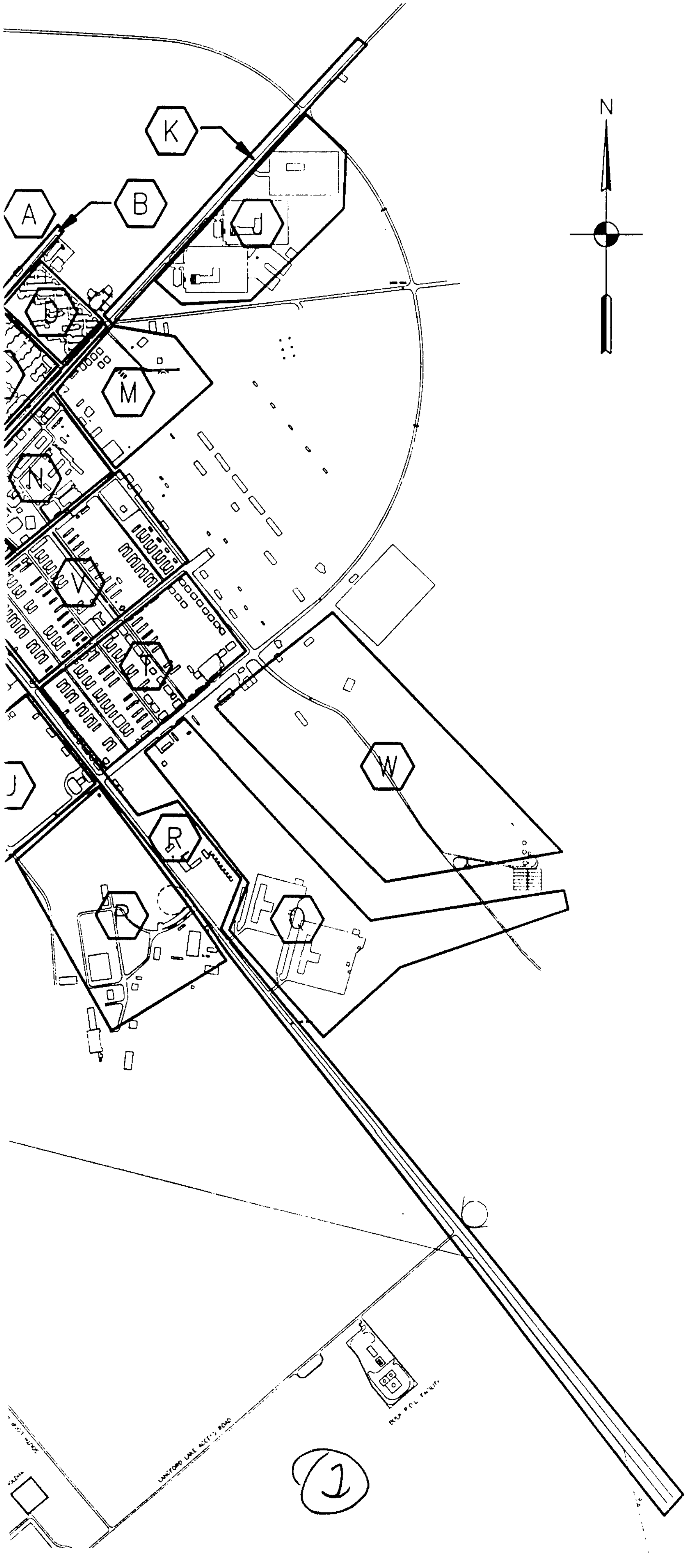

Area Identification	Industrial Area De
A	Inner Loop Road, Goldsto
B	Avenue B, Industrial Area
C	Barstow Road - Langford
D	5th - 7th / Barstow - Aven
E	4th - 5th / Barstow to Ave
F	3rd-1st / Barstow to Aven
G	Langford -1st / Barstow -
H	1 Million Gal UST Lines fr
I	Inner Loop - Ave B / 5th -
J	Vehicle Maint. Shops, Bar
K	Bicycle Lake Booster to 7
L	Bicycle Lake Booster / 7th
M	Barstow-7th / Sanitary - A
N	2nd - 5th / Barstow - Aver
O	Barstow-Langford / 2nd -
P	Depot Loop & Road off La
Q	Veh. Maint. Shops North
R	Lanford Road / Avenue F
S	South Loop Road, Langfo
T	5th - Langford / Ave F to
U	Langford Road to Avenue
V	5th - Langford / Ave F - A
W	5th from S. Loop Treatme

Figure 4
Domestic Water
Phased Replacer

0 800'
GRAPHIC SC

Area Identification	Industrial Area Description
A	Inner Loop Road, Goldstone to 5th
B	Avenue B, Industrial Area, Complete
C	Barstow Road - Langford to 7th
D	5th - 7th / Barstow - Avenue B
E	4th - 5th / Barstow to Avenue B
F	3rd-1st / Barstow to Avenue B
G	Langford -1st / Barstow - Avenue B
H	1 Million Gal UST Lines from Ave B
I	Inner Loop - Ave B / 5th - Goldstone
J	Vehicle Maint. Shops, Barstow Rd
K	Bicycle Lake Booster to 7th
L	Bicycle Lake Booster / 7th to Tanks
M	Barstow-7th / Sanitary - Avenue F
N	2nd - 5th / Barstow - Avenue F
O	Barstow-Langford / 2nd - Avenue F
P	Depot Loop & Road off Langford Rd
Q	Veh. Maint. Shops North of Langford
R	Lanford Road / Avenue F to ASD
S	South Loop Road, Langford to North
T	5th - Langford / Ave F to South Loop
U	Langford Road to Avenue F
V	5th - Langford / Ave F - Ave G
W	5th from S. Loop Treatment Plant

Figure 4-1
Domestic Water Distribution
Phased Replacement Areas

0 800' 1600'

GRAPHIC SCALE

3

Table 4-1
Summary of Water Leak Detection Survey Findings*
Fort Irwin, California

System/Leak Identification No.	Line Type	Location	Estimated Leakage (GPD)
Domestic - 1	Main	Barstow Rd. and 2nd Street	14,400
Domestic - 2	Main	Barstow Rd. and 2nd Street	28,800
Domestic - 3	Valve	Avenue B at 1st Street	4,320
Domestic - 4	Hydrant	South Loop at 3rd Ave.	2,880
Domestic - 5	Hydrant	5129C Rio Hondo Cove	1,080
Domestic - 6	Hydrant	Avenue B at 1st Street	1,080
Domestic - 7	Hydrant	Building No. 6030	1,080
Domestic - 8	Hydrant	Building No. 6045	1,080
Domestic - 9	Hydrant	Cambria at Rhineland	1,080
Domestic - 10	Hydrant	Silurian Hills Drive	1,080
Domestic - 11	Other	3732 Appomattox	360
Domestic - 12	Other	Avenue B and 5th Street	7,200
Domestic - 13	Other	Bldgs. 6017, 6032, 6047, 6057	28,800
Domestic -14	Other	5th Street - Building S594	7,200
		Total - Domestic Distribution	**100,440**
Reverse Osmosis - 1	Service	3724 Sicily	14,400
Reverse Osmosis - 2	Service	3809 Corregidor	7,200
Reverse Osmosis - 3	Valve	3721 Ardennes	7,200
		Total - RO Distribution	**28,800**

* Based on survey conducted 9 December through 13 December 1996

Table 4-2
Summary of Industrial Area
Domestic Water Distribution System Pipe Replacements

Industrial Area Description *	Total Cost	Year Built	Priority	Materials	Remarks
Area A - Inner Loop Road, Goldstone to 5th	$252,908	1966	4	AC	Meter & PRV Valve Boxes noted @ 1966
Area B - Avenue B, Industrial Area, Complete	$166,684	1966 ?	4	AC	Meter & PRV Valve Boxes noted @ 1966
Area C - Barstow Road - Langford to 7th	$290,519	1956 ?	2	AC	Based on data provided for nearby piping
Area D - 5th - 7th / Barstow - Avenue B	$85,460	1956 ?	2	AC	Based on data provided for nearby piping
Area E - 4th - 5th / Barstow to Avenue B	$243,960	1956	2	AC	
Area F - 3rd-1st / Barstow to Avenue B	$120,321	1956	2	AC & Transite	
Area G - Langford-1st / Barstow - Avenue B	$175,314	1966	4	AC	Meter & PRV Valve Boxes noted @ 1966
Area H - 1 Million Gal UST Lines from Ave B	$392,055	1952 ?	1	CI	Only one of 2 pipes identified
Area I - Inner Loop - Ave B / 5th - Goldstone	$229,006	1956	2	AC & Transite	Transite on Langford Road
Area J - Vehicle Maint. Shops, Barstow Rd	N/A	1985	-	-	NOT DONE, NEW PIPING
Area K - Bicycle Lake Booster to 7th	N/A	1967	-	AC	Not Done. Piping not leaking and in good shape
Area L - Bicycle Lake Booster / 7th to Tanks	N/A	1967	-	AC	Not Done. Piping not leaking and in good shape
Area M - Barstow-7th / Sanitary - Avenue F	$230,469	1965	4	AC	
Area N - 2nd - 5th / Barstow - Avenue F	$557,049	1956	2	AC	
Area O - Barstow-Langford / 2nd - Avenue F	$72,343	1956	2	AC	
Area P - Depot Loop & Road off Langford Rd	$402,030	1967	5	AC	
Area Q - Veh. Maint. Shops North of Langford	$704,345	1967 ?	5	AC ?	"Recent" newer facilities
Area R - Lanford Road / Avenue F to ASD	$635,950	1967 ?	5	AC ?	
Area S - South Loop Road, Langford to North	$161,781	1952	1	AC	Depth: 39-inches
Area T - 5th - Langford / Ave F to South Loop	$615,376	1952	1	AC	Depth: 39-inches
Area U - Langford Road to Avenue F	$185,160	1967	-	AC	
Area V - 5th - Langford / Ave F - Ave G	$637,177	1952	1	AC	Depth: 39-inches
Area W - 5th from S. Loop Treatment Plant	$207,799	1959	3	GI	

* Refer to Figure 4-1, Domestic Water Distribution Phased Replacement Areas, for proposed boundaries of each area.

F:\PROJ\1640321\ENGR\Newpipe1 Table 4-2

5.0 Ice Plant Water Savings and Precooling Retrofit

5.1 Description of Fort Irwin Ice Plant

The Fort Irwin ice plant consists of a Turbo Refrigerating Company Model TIGAR 50FL SCE ice generator, manufactured in 1993, having a nominal ice capacity of 50 tons per day. The ice plant, building No. 887, is located contiguous to Building No. 882, a cold storage warehouse. The ice making skid is situated on an elevated platform, 29 feet above grade. Sheets of ice generated by the ice machine are broken and conveyed into the warehouse and transferred to the rake. The broken sheet ice is further fragmented and sized prior to being bagged.

During the summer, the highest demand period, the plant is capable of producing only about 30 tons of ice per day. This reduced capacity is due, in part, to the elevated temperature of the feed water. Another problem is frequent jamming of the equipment. Feed water rises up a 2-inch diameter PVC pipe covered with one inch of fiberglass insulation. Reverse osmosis water enters the riser from underground at about 71 degrees F, but increases to about 88 degrees F before it reaches the ice plant. The temperature rise is due to conductive heat gain from hot desert air and radiant heat gain from the sun in the approximately 9 feet of vertical piping from ground level to the ice-making machine. The 50 ton per day rated capacity of the ice plant is based on 60 degree F supply water.

The ice sizer installed up-stream of the bagging operation rejects ice particles too fine to be bagged. These fines, or "snow," are discharged from the process by a shoot that protrudes from the building. This snow is allowed to melt and evaporate. In addition, there are two sources of cold wastewater loss: (1) purging or overflowing the water basin beneath the ice-making sheets in the ice generator to maintain water quality and (2) washing down the screw conveyor that transfers broken sheet ice into the building between cycles.

5.2 Proposed Water Savings and Precooling Retrofit

The snow and wastewater flows from the ice plant represent a potential source for waste heat recovery. It is proposed to collect these waste streams and precool feed water to the ice plant and to irrigate an adjacent area to be landscaped. The proposed retrofit will consist of the following items:

- Heat exchanger tank, nominally sized at 3500 gallons, to collect "snow" and wastewater
- Heat exchanger coils or stipple plate mounted inside tank
- Ice plant feed water piping modifications
- Waste water collection piping modifications
- Solar powered irrigation pump
- Concrete pad for the heat exchanger tank and irrigation pump

- Landscaping and irrigation piping

5.3 Analysis Methodology and Results

Two approaches could be taken to evaluate the benefits of this retrofit:

1. As an energy saving project, the ice plant operating efficiency is improved resulting in the same ice production with reduced electricity consumption and demand.

2. As an energy efficiency improvement project, the ice plant will produce more ice while consuming the same amount of energy. Cost benefits are achieved by avoiding the higher cost of purchased ice needed to meet the Post's requirements during high demand periods.

The Army has a five year contract with the operator of the ice plant to provide bag ice at a fixed price per bag each year: $0.80 per bag during FY97 and rising each year to $0.90 per bag during FY2001. The total cost to the Army for ice includes this per bag cost plus the cost of electric power and RO water to the ice plant. Accordingly, it would appear that improving the efficiency of the plant while maintaining the same production rate--approach no. 1--is more in the Army's interest.

Quantities of waste flows at full capacity and 24 hour per day operations that can be used to precool the ice machine supply water are estimated as follows:

- Ice maker overflow: 4,320 gallons per day of 32 degree F water

- Shoot wash water: 1,440 gallons per day of 45 degree F water

- Waste "snow": 7,500 pounds per day of 25 degree F ice

It is estimated that the feed water entering the ice plant will be cooled from 88 degrees F to 60.8 degrees F by the proposed heat exchanger. The energy difference between the existing and lower feed water temperatures at 50 tons per day capacity is estimated at 12.9 tons per day. At the rated coefficient of performance (COP) of 3.52, this yields a 12.8 kW savings when the plant operates at 100 percent. Estimated annual energy savings to maintain the current annual total ice production of 3,731 tons with the ice maker operating at its rated COP is 81,004 kWh.

With a total investment cost of $30,371, this retrofit will generate annual savings estimated at $5,276, a simple payback period of 5.76 years and a savings-to-investment ratio of 2.67. Refer to Appendix E for detailed savings calculations and construction cost estimate.

APPENDIX A

Scope of Work and Minutes of Project Meetings

CESPK-ED-M (415-10f)

SUPPLEMENTAL
SCOPE OF WORK

24 May 1996

SUBJECT: EEAP, FY 96 Fort Irwin, Water Conservation Study: Leak Detection Survey of Potable & Domestic Water Distribution Systems.

CONTRACT NUMBER: DACA05-C-92-0155

1. PROJECT DATA:

a. Installation: Fort Irwin, CA

b. A-E: Keller & Gannon
1453 Mission Street
San Francisco, CA 94103

POC: Mr. Richard Lennig
PHONE: (415) 621-1199
FAX: (415) 864-3681

c. Specification No.: N/A

d. Project Number: 351

e. Authorization: CEMP-ET Memo dated 28 Feb 1996, Subject: Energy Engineering Analysis Program (EEAP) - FY96 Program.

2. PROJECT DESCRIPTION AND BACKGROUND INFORMATION: This project consists of performing field investigations and analyses for a water conservation study to include leak detection and water meter installation. Fort Irwin which is in the desert area has a limited water supply and pumps water from 150 HP motors as much as 18 hours/day. Due to past earthquakes around the area water leaks have apparently increased and further pushed the water peak demand.

3. A-E WORK AND SERVICES:: General: The A-E shall provide all professional architectural and engineering services required for and related to the preparation, coordination and completion of all work described or specified herein. The work involved shall be as shown in paragraph 4.b. Functional Requirements and to include but not be limited to the following:

a. **Field Survey/Investigation:** The A-E shall review all project-related available as-built and utility plans for the Facility to aid in determining the existing site conditions. The A-E shall verify as-built plans as applicable if the site survey indicates a variance. The A-E shall conduct an on-site survey (other than the brief survey conducted during the pre-design conference) of the facility to verify current conditions. The A-E shall reflect in the study current conditions and actual existing services and equipment as verified from the field investigation. Ample time will be given the A-E to perform a thorough and complete investigation.

1) Review Previous Studies. Review the previous study titled "FORT IRWIN INTEGRATED RESOURCE ASSESSMENT VOL 3: SITEWIDE ENERGY PROJECT IDENTIFICATION FOR BUILDINGS AND FACILITIES," which applies to the specific building, system, or WCO covered by this study. This review should acquaint the AE with the work that has been performed previously. Much of the information the AE may need to develop the WCOs in this study may be contained in the previous study.

2) Perform a Site Survey. The AE shall obtain all necessary data to evaluate the WCOs or projects by conducting a site survey. Perform leak detection with the use of instrumentation to identify and localize the leak sources. Also provide permanent water meters to quantify flow and loss quantities. However, the AE is encouraged to use any data that may have been documented in a previous study. The AE shall document his site survey on forms developed for the survey, or on standard forms, and submit these completed forms as part of the report. All test and/or measurement equipment shall be properly calibrated prior to its use.

3) Reevaluate Selected Projects. The AE shall reevaluate the projects and WCOs for the aforementioned study. There maybe some projects recommended in that study that may contribute to this new water conservation study. These projects may identify WCOs which may have not been accomplished or have been only partially accomplished. If the project or WCO is acceptable as is, that is, there are no changes to the basic project or WCO, the energy savings shown in the previous project may be accepted as accurate but the energy cost and construction cost estimates shall be updated based on the most current data available. With the above information the project shall then be analyzed based on current ECIP criteria. If the project or WCO is basically acceptable but some of the buildings in the original project have been deleted or new buildings can be added, the necessary changes shall be made to the energy savings, the energy costs and construction costs shall be updated, and the revised project or WCO shall then be analyzed using current ECIP guidance. If the original project or WCO has had numerous changes made to it so that all of the numbers are suspected of being inaccurate, but the project or WCO is still considered feasible, the AE shall develop the project from the beginning and analyze it with the current ECIP guidance. These projects shall be separately listed in the report.

b. Interim Submittal. [Due 60 calendar days after Notice to Proceed (NTP)]. An interim report shall be submitted for review after the field survey has been completed and an analysis has been performed on all of the WCOs. The report shall indicate the work which has been accomplished to date, illustrate the methods and justifications of the approaches taken and contain a plan of the work remaining to complete the study. Calculations showing energy and dollar savings, SIR, and simple payback period of all the WCOs shall be included. The results of the WCO analyses shall be summarized by lists as follows:

1) All WCOs eliminated from consideration shall be grouped into one listing with reasons for their elimination.

2) All WCOs which were analyzed shall be grouped into two listings, recommended and non-recommended, each arranged in order of descending SIR. These

lists may be subdivided by building or area as appropriate for the study.

3) The AE shall submit the Scope of Work and any modifications to the Scope of Work as an appendix to the report. A narrative summary describing the work and results to date shall be a part of this submittal. At the Interim Submittal and Review Conference, the Government's and AE's representatives shall coordinate with the Director of Public Works to provide the AE with direction for packaging or combining WCOs for programming purposes and also indicate the fiscal year for which the programming or implementation documentation shall be prepared. The survey forms completed during this audit shall be submitted with this report. The survey forms only may be submitted in final form with this submittal. They should be clearly marked at the time of submission that they are to be retained. They shall be bound in a standard three-ring binder which will allow repeated disassembly and reassembly of the material contained within.

c. **Review Conference:** A one day review conference shall be held at the installation within 10 days after the receipt of the Government's review comments for the interim report.

d. Final Report Submittal: (Due 30 calendar days after receipt of Government review comments on the interim report). The AE shall prepare and submit the final report when all sections of the report are 100% complete and all comments from the interim submittal have been resolved. The AE shall submit the Scope of Work for the study and any modifications to the Scope of Work as an appendix to the submittal. The report shall contain a narrative summary of conclusions and recommendations, together with all raw and supporting data, methods used, and sources of information. The report shall integrate all aspects of the study. The recommended projects, as determined in accordance with this study , shall be presented in order of priority by SIR. The lists of WCOs specified shall also be included for continuity. The final report and all appendices shall be bound in standard three-ring binders which will allow repeated disassembly and reassembly. The final report shall be arranged to include:

1) An Executive Summary to give a brief overview of what was accomplished and the results of this study using graphs, tables and charts as much as possible.

2) The narrative report describing the problem to be studied, the approach to be used, and the results of this study.

3) Documentation for the recommended projects (includes LCCA Summary Sheets).

4) Appendices to include as a minimum:

a) Energy cost development and backup data

b) Detailed calculations

c) Cost estimates

d) Computer printouts

e) This Scope of Work

4. PROJECT CRITERIA:

a. **Functional Criteria:**

1) GSOW dated Feb 1995 (rev 24 May 96). (ENCL 1)

2) A-E Memo, Meeting Minutes, dated 30 Jan 1996 (ENCL 2)

b. **Functional Requirements:** The following project tasks shall be performed:

1) Determine the extent of repairs already completed by previous upgrade projects and field verify existing conditions. The field survey shall include an inspection of the water supply and distribution systems.

2) Establish the magnitude of losses in the supply and distribution lines due to leaks and deteriorated piping.

3) Evaluate alternative replacement strategies, including repair or replacement of pipes by trenchless construction, sliplining or by normal excavation/replacement procedures and determine the most cost effective alternative that satisfies mission needs. The life cycle economic analysis of each alternative shall include:

a) Estimated concept-level construction costs

b) Estimated life Cycle energy consumption and costs

c) Estimated life cycle maintenance costs

d) Life cycle cost analysis summary

c. **Criteria Documents:**

1) Architectural and Engineering Instruction DATED 3 July 1994.

2) A-E Guide Instruction for Army Projects, Volume 1, DATED January 1990.

3) A-E Guide, CESPK Cost Estimate Guide, Volume 2, DATED December 1989. This document shall be used as a guide for cost estimate format and content regardless of whether or not the Corps' software is used by the A-E.

4) A-E Guide Volume III, Specifications, DATED December 1990. ***NOTE*** THIS VOLUME IS TO BE USED ONLY AS INFORMATION EXCEPT WHERE SPECIFICALLY REFERENCED. IT IS NOT UP TO DATE. THE MOST CURRENT

SPECIFICATIONS ARE TO BE OBTAINED FROM THE CRITERIA BULLETIN BOARD. CONTACT STEVE FREITAS FOR ACCESS TO THE BULLETIN BOARD AT (916) 557-7296.

d. **Technical Criteria:**

1) Publications listed in A-E Guide, Vol. 1, General Instructions, Chapter V.

2) Corps of Engineers Guide Specifications obtained from the Criteria Bulletin Board.

3) ETL 1110-3-282, Energy Conservation.

4) Energy Conservation Investment Program (ECIP) Guidance, dated 10 Jan (6 SEPT 96 1994 and the latest revision with current energy prices and discount factors for life cycle cost analysis.

5) TM 5-785, Engineering Weather Data.

6) TM 5-800-2, General Criteria Preparation of Cost Estimates, or MCACES instructions

7) Other Army Technical Manuals (TMs) related to the design of systems addressed in this study.

8) AR 415-15, 1 Jan 84, Military Construction, Army (MCA) Program Development.

9) AR 420-10, 2 July 1987, Management of Installation Directorates of Engineering and Housing, and Future Change, dated 11 July 1994.

10) Latest MCP Index.

11) The following items shall be provided to the AE to the extent to which they are available: Coordinate with DEH for available copies.

a) As-built drawings of applicable buildings, equipment, or systems

b) Handbooks or SOPs relating to the operation of applicable equipment or systems.

c) Applicable records of energy or fuel usage.

d) Copies of bills for electrical energy or fuel purchases. Identify electrically or fuel pump driven water pumps.

The request for technical manuals, Army/Air Force publications, DOD manuals and Sacramento District prepared manuals can be made by calling the Sacramento District Technical Manager, Larry Gittings at (916) 557-7215 or faxing the request

to (916) 557-7850. Other references such as CFRs, other Government Agency publications and Industry Standards (ASCE, ASTM, AISC, NEMA, etc.) will not be available from the Corps of Engineers. Experienced A-Es generally have and/or are familiar with these references. Correspondence to the Sacramento District concerning this project shall be sent to the following address:

U.S. Army Corps of Engineers
Sacramento District
ATTN: CESPK-ED-M, Larry Gittings
1325 J Street
Sacramento, CA 95814-2922

5. DISTRIBUTION LIST: Report submittal and distribution shall be as specified below:

Name & Address	Number of Copies	
U.S. Army Corps of Engineers Mobile District/CESAM-EN-DM Attn: Mr. Tony Battaglia 109 St. Joseph Street Mobile, AL 36602 PH: (334) 690-2618 FAX: (334) 690-2424	1	U.S. Army Corps of Engineers Mobile District/CESAM-EN-DM P.O. Box 2288 Mobile, AL 36628-0001 (Alternate Address)
National Training Center Directorate of Public Works Attn: AFZJ-DPW (Mr. Rene Quinones) Building Ft. Irwin, CA 92310-5000 PH: (619) 380-3433 FAX: (619) 380-5293	6	
US Army Corps of Engineers South Pacific Division CESPD-ET-ET Attn: Mr. Foo Eng 333 Market Street Room 923 San Francisco, CA 94105	1	
US Army Corps of Engineers Sacramento District CESPK-ED-M (Army/ISS Section) Attn: Mr. Larry Gittings 1325 J Street Sacramento, CA 95814-2922 PH: (916) 557-7215 FAX: (916) 557-7850	3	

Commander
US Army Corps of Engineers
Attn: CEMP-ET (Mr. Dan Gentil)
20 Massachusetts Ave., NW
Washington DC, 20314-1000

1 copy final
Executive summary only

Commander
HQ FORSCOM
Attn: AFPI-ENO (Mr. N. Kapur)
Ft. McPherson, GA 30330-6000
PH: (404) 669-5327

1

6. <u>REVIEW & CORRECTION PROCESS:</u>

a. The review process and annotation of comments shall be performed using the Automated Review Management System (ARMS). ARMS is a computerized method for transmittal and storage of review comments. Contact <u>JAE KIM</u> at (916) 557-7218 for an access password and instructions. Further guidelines for the review process are provided in A-E Guide, Vol I, Chapter 1.

b. Upon completion of the Government review, all review comments will be transmitted to the A-E via ARMS. The submittal shall be prepared in accordance with the format and instructions contained in the enclosure, General Scope of Work (GSOW). Upon completion of corrections in accordance with review comments, the A-E shall submit all corrected original documents, including annotated review comments with rebuttals (if any) to addresses in the Distribution list. Where prepared in electronic media, drawings, specifications and engineering data shall also be submitted in such format in addition to the hard (paper) copies. If discrepancies still exist all original documents will be returned to the A-E for resolution of discrepancies. Thereafter the A-E resubmit all the original documents and same quantity as before of the printed sets of all documents.

7. <u>PERIODS OF SERVICE:</u> The periods of service shall be as specified hereinbefore. The periods of service do not include Government review time, but do include transmittal time from the A-E to the Sacramento District Technical Manager. Additionally, close coordination shall be maintained with the Sacramento District Technical Manager to insure quick response and resolution to any questions or problems that may be encountered during the course of this design which deviates from the requirements stated in this Scope of Work. The A-E shall immediately notify the Sacramento District Technical Manager of any such requests.

8. The A-E is cautioned to take no guidance from any source other than the Contracting Officer during the course of this design which deviates from the requirements stated in this Scope of Work. The A-E shall immediately notify the Sacramento District Technical Manager of any such requests.

ALEXANDER L. AZARES
Technical Manager

ENCLOSURE:

1. GENERAL SCOPE OF WORK (GSOW) FOR A WATER SAVINGS OPPORTUNITY SURVEY (WSOS)
2. A-E MEMO, DATED 30 JAN 96

DISTRIBUTION:

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Weath.

CESAM-EN-DM

February 1995
(Revised 24 May 1996)

GENERAL SCOPE OF WORK

FOR A

WATER SAVINGS OPPORTUNITY SURVEY (WSOS)

Performed as part of the

ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)

GSOWWCIR.WIN

SCOPE OF WORK
FOR A
WATER SAVINGS OPPORTUNITY SURVEY

TABLE OF CONTENTS

ANNEXES

GENERAL SCOPE OF WORK (GSOW)

1. BRIEF DESCRIPTION OF WORK: The Architect-Engineer (AE) shall:

1.1 Review for general information the report, "Fort Irwin Integrated Resource Assessment, Vol. 3: Sitewide Energy Project Identification for Buildings and Facilities," dated Feb 1995 , by Battelle Pacific NW Laboratory, DYNCORP's Ft. Irwin Water Well Reports and Ft. Irwin Reverse Osmosis Water Treatment Report, and any other energy and/or water studies which were performed at this installation.

1.2 Perform a limited site survey of selected buildings or areas to insure that any methods of water conservation which are practical and have not been evaluated in any previous energy study have been considered and the results documented.

1.3 Reevaluate selected projects and water conservation opportunities (WCOs) from the previous studies to determine their economic feasibility based on revised criteria, current site conditions and technical applicability.

1.4 Evaluate selected WCOs to determine their savings potential and economic feasibility.

1.5 Provide complete programming or implementation documentation for all recommended WCOs.

1.6 Prepare a comprehensive report to document the work performed, the results and the recommendations.

2. GENERAL

2.1 Some installations may purchase water from a public utility company; some may operate complete systems including wells, treatment plants, and distribution systems. Some may have hybrid systems. In any case, water conservation opportunities must be evaluated on a monetary basis. That is, the total life-cycle cost, including cost savings from water, energy, supplies, maintenance, even the avoided cost of waste water treatment, is to be considered when evaluating the viability of a WCO.

2.2 Other studies performed under the EEAP have been performed at this installation. Criteria for both the study and the resulting documentation has changed since the previous study was completed. This study is intended to focus on water saving opportunities. This may require the reevaluation of selected projects from the previous study which have not been implemented nor programmed for implementation and the consideration of specific WCOs in buildings and areas that may have been overlooked previously or recently identified. In particular, water conservation opportunities which may not have associated energy savings are to be considered.

2.3 The information and analysis outlined herein are considered to be minimum essentials for adequate performance of this study.

2.4 The AE shall ensure that all methods of water conservation which will reduce the water consumption of the installation in compliance with the provisions of Executive Order 12902, including those listed in Annexes A and B, have been considered and documented. All methods of water conservation which are reasonable and practical shall be considered, including improvements of operational methods and procedures as well as the physical facilities. All water conservation opportunities which produce water, energy, or dollar savings shall be documented in this report. Any water conservation opportunity considered infeasible shall also be documented in the report with reasons for elimination. A list of general water conservation opportunities to be used when evaluating specific buildings or areas is included as Annex A to this scope. Annex B contains a list of WCOs specifically for this installation. Both of these lists shall be considered and the evaluation of each WCO documented in the report. These lists are not intended to be restrictive but only to assure that basic and generally repetitive opportunities are addressed in the report. The AE may be aware of other WCOs not included in Annex A or Annex B that will produce water, energy, manpower, or dollar savings. These should be evaluated the same as the listed WCOs. Some of the water conservation opportunities in Annex A may not be applicable to the specific building or area under study. A statement to that effect is all that is required.

2.5 The study shall include the buildings or areas listed in Annex B.

2.6 The "Energy Conservation Investment Program (ECIP) Guidance", described in letter from DAIM-FDF-U, dated 10 Jan 1994 (including current updates) establishes criteria for ECIP projects and shall be used for performing the economic analyses of <u>all</u> WCOs and projects. The program, Life Cycle Cost In Design (LCCID), has been developed for performing life cycle cost calculations in accordance with ECIP guidelines and is referenced in the ECIP Guidance. If any program other than LCCID is proposed for life cycle cost analysis, it must use the mode of calculation specified in the ECIP Guidance. The output must be in the format of the ECIP LCCA summary sheet, and it must be submitted for approval to the Contracting Officer. Construction cost escalation for DD Form 1391 submission shall be calculated using the guidelines contained in AR 415-17 and the latest Tri-Service MCP Index.

2.7 In performing life cycle cost analyses of WCOs, care must be exercised to avoid taking double credit for energy cost savings. For example: If a unit cost is developed for water that includes the cost of energy used in producing the water, the energy savings (MBTU) associated with the water saved may be claimed; but the cost of that energy cannot be claimed, because it is already included in the water cost savings.

2.8 Computer modeling will be used to simulate flows and pressure drops in water distribution piping or to evaluate water resources and requirements. The Detailed Scope of Work, Annex B, will list programs that are acceptable to the Contracting Officer. If the AE desires to use a different program, it must be submitted for approval with a sample run, an explanation of all input and output data, and a summary of program methodology and evaluation capabilities.

2.9 Water conservation opportunities determined to be technically and economically feasible shall be developed into projects acceptable to installation

personnel. This may involve combining similar WCOs into larger packages which will qualify for ECIP or FEMP funding, and determining, in coordination with installation personnel, the appropriate packaging and implementation approach for all feasible WCOs.

2.9.1 Projects which qualify for ECIP funding shall be identified, separately listed, and prioritized by the Savings to Investment Ratio (SIR).

2.9.2 All feasible non-ECIP projects shall be ranked in order of highest to lowest SIR.

2.9.3 At some installations Energy Conservation and Management (ECAM) funding will be used instead of ECIP funding. The criteria for each program is the same. The Director of Public Works will indicate which program is used at this installation. This Scope of Work mentions only ECIP, however, ECAM is also meant.

2.10 Metric Reporting Requirements: In this study, the analyses of the ECOs may be performed using English or Metric units as long as they are consistent throughout the report. The final results of energy savings for individual recommended projects and for the overall study will be reported in units of MegaBTU per year <u>and</u> in MegaWatts per year. The final results of water savings shall be reported in gallons <u>and</u> cubic meters per year. Paragraph 7.6.2 details requirements for the contents of the final submittal.

3. <u>PROJECT MANAGEMENT</u>

3.1 <u>Project Managers</u>. The AE shall designate a project manager to serve as a point of contact and liaison for work required under this contract. Upon award of this contract, the individual shall be immediately designated in writing. The AE's designated project manager shall be approved by the Contracting Officer prior to commencement of work. This designated individual shall be responsible for coordination of work required under this contract. The Contracting Officer will designate a project manager to serve as the Government's point of contact and liaison for all work required under this contract. This individual will be the Government's representative.

3.2 <u>Installation Assistance</u>. Point of Contact (POC) at the installation Is Mr. Rene Quinones and will be assisting in establishing contacts with the proper individuals and organizations as necessary to accomplish the work required under this contract.

3.3 <u>Public Disclosures</u>. The AE shall make no public announcements or disclosures relative to information contained or developed in this contract, except as authorized by the Contracting Officer.

3.4 <u>Meetings</u>. Meetings will be scheduled whenever requested by the AE or the Contracting Officer for the resolution of questions or problems encountered in the performance of the work. The AE and/or the designated representative(s) shall be required to attend and participate in all meetings pertinent to the work required under this contract as directed by the Contracting Officer. These meetings, if necessary, will be in addition to the presentation and review

conferences.

3.5 Site Visits, Inspections, and Investigations. The AE shall visit and inspect/investigate the site of the project as necessary and required during the preparation and accomplishment of the work.

3.6 Records

3.6.1 The AE shall provide a record of all significant conferences, meetings, discussions, verbal directions, telephone conversations, etc., with Government representative(s) relative to this contract in which the AE and/or designated representative(s) thereof participated. These records shall be dated and shall identify the contract number, and modification number if applicable, participating personnel, subject discussed and conclusions reached. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the records.

3.6.2 The AE shall provide a record of requests for and/or receipt of Government-furnished material, data, documents, information, etc., which if not furnished in a timely manner, would significantly impair the normal progression of the work under this contract. The records shall be dated and shall identify the contract number and modification number, if applicable. The AE shall forward to the Contracting Officer within ten calendar days, a reproducible copy of the record of request or receipt of material.

3.7 Interviews. The AE and the Government's representative shall conduct entry and exit interviews with the Director of Public Works before starting work at the installation and after completion of the field work. The Government's representative shall schedule the interviews at least one week in advance.

3.7.1 Entry. The entry interview shall describe the intended procedures for the survey and shall be conducted prior to commencing work at the facility. As a minimum, the interview shall cover the following points:

a. Schedules.

b. Names of analysts who will be conducting the site survey.

c. Proposed working hours.

d. Support requirements from the Director of Public Works.

3.7.2 Exit. The exit interview shall be held when the field work is essentially complete; it shall briefly describe the items surveyed and probable areas of water and energy conservation. The interview shall also solicit input and advice from the Director of Public Works.

4. SERVICES AND MATERIALS. All services, materials (except those specifically enumerated to be furnished by the Government), labor, supervision and travel necessary to perform the work and render the data required under this contract are included in the lump sum price of the contract.

5. PROJECT DOCUMENTATION. All water conservation opportunities which the AE has considered shall be included in one of the following categories and presented in the report as such:

5.1 ECIP Projects. To qualify as an ECIP project, an WCO, or several WCOs which have been combined, must have a construction cost estimate greater than $300,000, a Savings to Investment Ratio (SIR) greater than 1.25 and a simple payback period of less than ten years. The overall project and each discrete part of the project shall have an SIR greater than 1.25. All projects meeting the above criteria shall be arranged as specified in paragraph 2.9.1 and shall be provided with programming documentation. Programming documentation shall consist of a DD Form 1391 and life cycle cost analysis (LCCA) summary sheet(s) (with necessary backup data to verify the numbers presented). A life cycle cost analysis summary sheet shall be developed for each WCO and for the overall project when more than one WCO are combined. The energy and water savings for projects consisting of multiple WCOs must take into account the synergistic effects of the individual WCOs.

5.2 Non-ECIP Projects. Projects which do not meet ECIP criteria with regard to cost estimate, but which have an SIR greater than 1.25 shall be documented. Projects or WCOs in this category shall be arranged as specified in paragraph 2.9.2 and shall be provided with the following documentation: the life cycle cost analysis (LCCA) summary sheet completely filled out, a description of the work to be accomplished, backup data for the LCCA, ie, energy and water savings calculations and cost estimate(s), and the simple payback period. The energy and water savings for projects consisting of multiple WCOs must take into account the synergistic effects of the individual WCOs. In addition these projects shall have the necessary documentation prepared, as required by the Government's representative, for one of the following categories:

a. Federal Energy Management Program (FEMP) Projects. A FEMP (or O&M Energy) project is one that results in needed maintenance or repair to an existing facility, or replaces a failed or failing existing facility, and also results in energy or water savings. The criteria are similar to the criteria for ECIP projects, ie, SIR $\geq$ 1.25, and simple payback period of less than ten years. Projects with a construction cost estimate up to $1,000,000 shall be documented as outlined in par 5.2 above; projects over $1,000,000 shall be documented on 1391s. In the FEMP program, a system may be defined as "failed or failing" if it is inefficient or technically obsolete. However, if this strategy is used to justify a proposed project, the equipment to be replaced must have been in use for at least three years.

b. Low Cost/No Cost Projects. These are projects which the Director of Public Works (DPW) can perform using his resources. Documentation shall be as required by the DPW.

5.3 Nonfeasible WCOs. All WCOs which the AE has considered but which are not feasible, shall be documented in the report with reasons and justifications showing why they were rejected.

6. DETAILED SCOPE OF WORK. The Detailed Scope of Work is contained in Annex B. The standard Sacramento District's scope is in CESPK-ED-M SCOPE OF WORK which

contains all the attachments.

7. WORK TO BE ACCOMPLISHED.

7.1 Review Previous Studies. The AE shall review for general information the previous EEAP study along with any other energy and/or water studies performed at the installation. This review should acquaint the AE with the work that has been performed previously. Much of the information the AE may need to develop the WCOs in this project will be contained in the previous studies.

7.2 Perform a Limited Site Survey. The AE shall obtain all necessary data to evaluate the WCOs or projects by conducting a site survey. However, the AE is encouraged to use any data that may have been documented in a previous study. The AE shall document his site survey on forms developed for the survey, or standard forms, and submit these completed forms as part of the report. All test and/or measurement equipment shall be properly calibrated prior to its use.

7.3 Reevaluate Selected Projects. The AE shall reevaluate the projects and ECOs listed in Annex B.

7.4 Evaluate New WCOs. These WCOs shall be analyzed in detail to determine their feasibility. Savings to Investment Ratios (SIRs) shall be determined using current ECIP guidance. The AE shall provide all data and calculations needed to support the conclusions. All assumptions shall be clearly stated. Calculations shall be prepared showing how all numbers in the WCO were figured. Calculations shall be an orderly step-by-step progression from the first assumption to the final number. Descriptions of the products, manufacturers catalog cuts, pertinent drawings and sketches shall also be included. A life cycle cost analysis summary sheet shall be prepared for each WCO and included as part of the supporting data. The following classes of WCOs are included:

a. General WCOs: The list of WCOs in Annex A shall be evaluated for the buildings or areas listed in Annex B. Those items on the list which are not practical, have been previously accomplished, are inappropriate or can be eliminated from detailed analysis based on preliminary analysis shall be listed in the report along with the reason for elimination from further analysis. All potential WCOs which are not eliminated by preliminary considerations shall be thoroughly documented and evaluated as to technical and economic feasibility.

b. Selected WCOs: These are the specific WCOs which are listed in Annex B.

c. Contractor-identified WCOs: These are those WCOs which the AE is aware of or notes during the field survey that are not included in Annex A or Annex B but will produce water savings and energy, manpower or dollar savings. These should be evaluated the same as the listed WCOs.

7.5 Provide Programming or Implementation Documentation. During the Interim Review Conference, as outlined in paragraph 7.6.1, the AE will be advised of the DPW's preferred packaging of recommended WCOs into projects for implementation. These projects will be documented as outlined in paragraphs 5.1, 5.2, and 5.3. Programming documentation will be included in the Interim Submittal per par

7.6.1. Programming documents shall be separate from the narrative report, and they shall be bound similarly to the final report in a manner which will facilitate repeated disassembly and reassembly.

7.6 Submittals, Presentations and Reviews. The work accomplished shall be fully documented by a comprehensive report. The report shall have a table of contents and be indexed. Tabs and dividers shall clearly and distinctly divide sections, subsections, and appendices. All pages shall be numbered. The AE shall give a formal presentation of all but the final submittal to installation, command, and other Government personnel. The AE shall prepare slides or view graphs showing the results of the study to date for his presentation. During the presentation, the personnel in attendance shall be given ample opportunity to ask questions and discuss any changes deemed necessary to the study. A review conference will be conducted the same day, following the presentation. Each comment presented at the review conference will be discussed and resolved or action items assigned. It is anticipated that the presentation and review conference will require approximately one working day. Presentation and review conferences will be at the installation on the date agreeable to the DPW, the AE and the Government's representative. The Contracting Officer may require a resubmittal of any document(s), if such document(s) are not approved because they are determined by the Contracting Officer to be inadequate for the intended purpose.

7.6.1 Interim Submittal. An interim report shall be submitted for review after the field survey has been completed and an analysis has been performed on all of the WCOs. The report shall indicate the work which has been accomplished to date, illustrate the methods and justifications of the approaches taken and contain a plan of the work remaining to complete the study. Calculations showing water, energy, and dollar savings, SIRs, and simple payback period of all the WCOs shall be included. The results of the WCO analyses shall be summarized by lists as follows:

a. All WCOs eliminated from consideration shall be grouped into one listing with reasons for their elimination as discussed in par 5.3.

b. All WCOs which were analyzed shall be grouped into two listings, recommended and non-recommended, each arranged in order of descending SIR. These lists may be subdivided by building or area as appropriate for the study. The AE shall submit the Scope of Work and any modifications to the Scope of Work as an appendix to the report. A narrative summary describing the work and results to date shall be a part of this submittal. At the Interim Submittal and Review Conference, the Government's and AE's representatives shall coordinate with the DPW to provide the AE with direction for packaging or combining WCOs for programming purposes and also to indicate the fiscal year for which the programming or implementation documentation shall be prepared. Survey forms completed during this audit shall be submitted with this report. The survey forms only may be submitted in final form with this submittal. They should be clearly marked for retention at the time of submission. They shall be bound in a standard three-ring binder which will allow repeated disassembly and reassembly of the material contained within. The report shall contain a narrative summary of conclusions and recommendations, together with all raw and supporting data, methods used, and sources of information. The report shall integrate all aspects

of the study. The report shall include an order of priority by SIR in which the recommended WCOs should be accomplished. Completed programming and implementation documents for all recommended projects shall be included. The programming and implementation documents shall be ready for review and signature by the installation commander. The interim report, separately bound Executive Summary and all appendices shall be bound in standard three-ring binders which will allow repeated disassembly and reassembly. The interim submittal shall be arranged to include (a) a separately bound Executive Summary to give a brief overview of what was accomplished and the results of this study using graphs, tables and charts as much as possible (See Annex D for minimum requirements), (b) the narrative report containing a copy of the Executive Summary at the beginning of the volume and describing in detail what was accomplished and the results of this study, (c) appendices to include the detailed calculations and all backup material and (d) the programming and implementation documentation. A list of all projects and WCOs developed during this study shall be included in the Executive Summary and shall include the following data from the life cycle cost analysis summary sheet: the cost (construction plus SIOH), the annual energy and water savings, the annual dollar savings, the SIR, the simple payback period and the analysis date. For each programmed project also include the program year.

7.6.2 Final Submittal. Any revisions or corrections resulting from comments made during the review of the prefinal report or during the presentation and review conference shall be incorporated into the final report. These revisions or corrections may be in the form of replacement pages, which may be inserted in the prefinal report, or complete new volumes. Pen and ink changes or errata sheets will not be acceptable. If replacement pages are to be issued, it shall be clearly stated with the prefinal submittal that the submitted documents will be changed only to comply with the comments made during the prefinal conference and that the volumes issued at the time of the prefinal submittal should be retained. Failure to do so will require resubmission of complete volumes. If new volumes are submitted, they shall be in standard three-ring binders and shall contain all the information presented in the prefinal report with any necessary changes made. Detailed instructions of what to do with the replacement pages should be securely attached to the replacement pages.

ANNEX A

GENERAL WATER CONSERVATION OPPORTUNITIES

IRRIGATION

- Restrictions on time and duration of irrigation
- Use of moisture sensors and/or timers to control irrigation
- Conduct a landscape irrigation audit and develop an irrigation schedule to match the turf's water needs
- Use of reuse water
- Use of collected rainwater
- Irrigate with emitters, drip or misters, instead of spray irrigation
- Use sludge from treatment plants (highly stabilized) on irrigation areas to help with ground moisture retention (and require less water)
- Install separate water wells in a shallow or non-potable aquifer to eliminate irrigation water taken from potable aquifer
- Landscaping with low-maintenance plants (xeriscape)

HOUSING/ADMIN BUILDINGS

- Locate and repair leaks in exterior water lines/laterals

INDUSTRIAL

- Locate and repair leaks in the water distribution system
- Locate and repair leaks in the steam distribution and condensate return systems
- Increase cycles of concentration in boilers and cooling towers by improving or altering chemical treatment
- Automate blowdown/chemical feed on cooling towers
- Use high-pressure, hot water, low volume cleaning tools in maintenance areas.

GOLF COURSES

- Use reuse water only for irrigation

ANNEX B

DETAILED SCOPE OF WORK

1. This study is primarily a leak detection study to identify, isolate and repair the water supply and distribution system to include repairs to piping, machinery equipment or process. Study and repairs will be in support of the installation Energy Conservation Program.

2. It is recognized that MCA projects have already been programmed to renovate the water distribution in the Housing Areas. Water and other utility demand and consumption levels increase dramatically during the twelve (12) yearly training exercises. When the troops return to the Post from the field, the population increases from 4,000 to 8,000.

3. Reference ENCL 2 for particular requirements of this scope of work. Areas and taskings to be considered are:

a. Leak Detection in the Main Post (Cantonment) Area. Most water mains are PVC (all new construction) or asbestos cement. There are some old steel mains that still remain.

b. Investigate the "domestic" or "potable" water system. This system contains high levels of fluoride with is mains pressurized to 150 - 180 psig and PRVs at all buildings to reduce pressure below 80 psig.

c. Investigate the reverse osmosis (RO) distribution system. This system contains defluoridized water. he RO water is distributed to the Main Post drinking fountains, dining facilities, the Ice Plant and the TASE Photo Shop.

d. Water distribution to the Sewage Treatment Plant should be investigated. Records show flows to the Plant of 1.2 million gallons per day of which 100,000 gallons is brine from the RO plant.

e. The current TASE building requirement for 5,000 gallons per day of RO water will be eliminated when the photo shop is converted to computer generated graphics.

f. The study should include water/energy conservation to the Ice Plant. The plant was designed for 40 tons/day and the total demand for ice during the summer exercise periods is 80 tons/day. The cause of the lower-than design output is the high temperature of the feed water: 80 to 88 degrees F. The study should evaluate a project to pre-cool the feed water using waste "snow" from the ice making process. Since pre-cooling is only needed during hot daytime periods, photovoltaic modules could be used to power a circulating pump. Overflow of melted "snow" would be used for irrigating plantings.

g. The study should also look into rooms to improve operational procedures. The Fire Department performs annual dynamic flow tests at all hydrants.

h. Investigate methods to fool proof sprinkler heads. Reports indicate that numerous irrigation water leaks are caused by coyotes digging at sprinkler heads, with water pressure blowing off the damaged plastic fittings.

i. Consider in the life cycle cost analyses the possibility of Ft. Irwin purchasing wheeled power in 1999.

4. Performance Requirements:

a. Interim Report Submittal: Due 60 calendar days after Notice to Proceed.

b. Review Conference: One day review to be scheduled at the installation within 10 days after the receipt of the Government's review comments for the interim report.

c. Final Report Submittal: Due 30 calendar days after receipt of Government review comments on the interim report.

d. Submittal requirements and Distribution List are identified in paragraph 5. of SPK-ED-M SCOPE OF WORK.

e. Government-furnished information.

(1) Ft. Irwin Water Well Report for December 1995 and Ft. Irwin Reverse Osmosis Water Treatment Report for December 1995, both dated 9 Jan 1996, DYNCORP. Check with the installation for availability of earlier or most current reports.

(2) Final reports of other water conservation or energy studies completed.

(3) Architectural and Engineering Instructions, Chapter 15, Plumbing, 18 Sept 1992.

(4) Energy Conservation Investment Program (ECIP) Guidance, dated 10 Jan 1994 and the latest revision with current energy prices and discount factors for life cycle cost analysis.

(5) TM 5-810-5, Plumbing, 31 Aug 1993.

(6) TM 5-813-5, Water Supply - Water Distribution, 3 Nov 1986.

(7) TM 5-800-2, General Criteria Preparation of Cost Estimates, or MCACES instructions if required by your district.

(8) Other Army Technical Manuals (TMs) and Engineer Technical Letters (ETLs) related to the design of systems addressed in this study.

(9) AR 415-15, 1 Jan 84, Military Construction, Army (MCA) Program Development.

(10) AR 420-10, 2 July 1987, Management of Installation Directorates of Engineering and Housing, and Future Change, dated 11 July 1994.

(11) Latest MCP Index.

(12) The following items will be provided to the AE to the extent to which they are available:

(a) As-built drawings of applicable buildings, equipment, or systems

(b) Handbooks or SOPs relating to the operation of applicable equipment or systems.

(c) Applicable records of water consumption or fuel usage.

(d) Copies of water bills or other records needed for developing unit costs for water.

(e) Domestic Water System Drawings, 1" = 200'

(f) RO Water System Drawings, 1" = 200'

(g) Defluoridation Plant, Process and Instrumentation Diagram.

5. Some acceptable simulation programs follow (The A-E is not limited to these programs):

a. KY Pipe

b. IWRAPS, Installation Water Resources Analysis and Planning System

6. A computer program titled Life Cycle Costing in Design (LCCID) is available from the BLAST Support Office in Urbana, Illinois for a nominal fee. This computer program can be used for performing the economic calculations for ECIP and non-ECIP WCOs. The AE is encouraged to obtain and use this computer program. The BLAST Support Office can be contacted at 144 Mechanical Engineering Building, 1206 West Green Street, Urbana, Illinois 61801. The telephone number is (800) 842-5278.

ANNEX C

REQUIRED DD FORM 1391 DATA

To facilitate ECIP project approval, the following supplemental data shall be provided:

a. In title block clearly identify projects as "ECIP."

b. Complete description of each item of work to be accomplished including quantity, square footage, etc.

c. A comprehensive list of buildings, zones, or areas including building numbers, square foot floor area, designated temporary or permanent, and usage (administration, patient treatment, etc.).

d. List references, and assumptions, and provide calculations to support dollar and water or energy savings, and indicate any added costs.

(1) If a specific building, system, or area is used for sample calculations, identify building or area, category, square footage, floor area, (linear footage/capacity) for each.

(2) Identify data source(s).

(3) Identify assumptions before and after improvements.

(4) Include source of expertise and demonstrate savings claimed. Identify any special or critical environmental conditions.

e. An ECIP life cycle cost analysis summary sheet as shown in the ECIP Guidance shall be provided for the complete project and for each discrete part included in the project. The SIR is applicable to all segments of the project. Supporting documentation consisting of basic engineering and economic calculations showing how savings were determined shall be included.

f. The DD Form 1391 face sheet shall include, for the complete project, the annual dollar, water, and MBTU savings, SIR, simple amortization period and a statement attesting that all buildings and retrofit actions will be in active use throughout the amortization period.

g. The calendar year in which the cost was calculated shall be clearly shown on the DD Form 1391.

h. For each temporary building included in a project, separate documentation is required showing (1) a minimum 10-year continuing need, based on the installation's annual real property utilization survey, for active building retention after retrofit, (2) the specific retrofit action applicable and (3) an economic analysis supporting the specific retrofit.

i. Nonappropriated funded facilities will not be included in an ECIP project

without an accompanying statement certifying that utility costs are not reimbursable.

j. Any requirements required by ECIP guidance dated 10 January 1994 and any revisions thereto. Note that unescalated costs/savings are to be used in the economic analyses.

k. The five digit category number for all ECIP projects except for Family Housing is 80000. The category code number for Family Housing projects is 71100.

ANNEX D

<u>EXECUTIVE SUMMARY GUIDELINE</u>

1. Introduction.

2. Building/System Data (types, number of similar buildings, sizes, etc.)

3. Present Water/Energy Consumption.

   - o Total Annual Water and Associated Energy Used.
   - o Water - Gallons, Dollars
   - o Fuels (associated with water production or use) - QTY, Dollars, BTU
   - o Water Consumption of the buildings in this study as compared to the basewide consumption.

4. Historical Water/Energy Consumption.

5. Reevaluated Projects Results.

6. Water Conservation Analysis.

   - o WCOs Investigated.
   - o WCOs Recommended.
   - o WCOs Rejected. (Provide economics or reasons)
   - o ECIP Projects Developed. (Provide list)*
   - o Non-ECIP Projects Developed. (Provide list)*
   - o Operational or Policy Change Recommendations.

7. Water/Energy and Cost Savings.

   - o Total Potential Water/Energy and Cost Savings.
   - o Percentage of Water Conserved.
   - o Water/Energy Use and Cost Before and After the Water Conservation Opportunities are Implemented.

8. Water Conservation Plan.

   - o Project Breakouts with Total Cost and SIR.
   - o Schedule of Water Conservation Project Implementation

Include the following data from the life cycle cost analysis summary sheet: the cost (construction plus SIOH), the annual water/energy savings (type and amount), the annual dollar savings, the SIR, the simple payback period and the analysis date. For all programmed projects also include the program year.

CESAM-EN-DM

February 1996

INFORMATION FOR PARTICIPANTS IN THE FY96 EEAP

1. So far, everything about the FY96 EEAP is running late, but FY95 went pretty well. We had thirty-one studies in progress at the beginning of the year. Twenty-three of the studies are complete, 7 are still in progress, and one was deferred to FY96. Twenty-three new studies were initiated in FY95, twenty for AEs and three for CERL. During the year, one study was cancelled due to base closure, another was modified due to base realignment, and two were added; thereby a total of 21 were awarded to AEs. Of the three CERL studies, one is complete, and two are still in progress. Congratulations to everyone who worked to get these studies completed and awarded on schedule.

2. Funds Disbursement: Funds for in-house efforts are being disbursed by MIPR as in previous years. However, since we are not receiving the full amount that we expected and further cuts may be imminent, we are not sending the funds out in equal quarterly allotments. Rather, we have sent out funds which should be adequate for the first quarter, and are expecting each district to let us know when and how much will be needed as the year progresses. Funds for award of studies will be made available when negotiations have been completed and the studies are ready for award.

3. Supplemental Studies: Last year, $2.2M in supplemental funds were received. This year, $1.1M has been programmed; but so far none has been received, and with all of the current budget turmoil, we may not receive any supplemental funds. However, our program is set up for about 20% more than the $1.1M. We should proceed with preparation for these studies so we will be ready to award them if and when funds become available. It is not unusual for funds to become available near the end of the fiscal year, thereby we want be ready to accept and use them if offered.

4. AE Contracting: The four IDT contracts awarded by Mobile in June of 1994 have been working quite well, but all four will expire in June of 1996. We are setting up four new contracts. CBD announcements have been made, proposals are being received, and selection process starts in early February. The boundaries of the geographical regions have been revised, based on projected workloads, to keep the work in each region more or less equal. One Corps representative from each region has been invited to participate in the AE selection. This will be a different group than last time to try to equalize that work also. We hope to have all four contracts awarded by the end of June. Keep in mind, things do not always go as planned;

ENCL 1

so if we don't have the IDT contracts awarded by the end of June, any studies which have not been awarded may have a long wait. It would be wise to get those studies ready to award in May or early June.

5. As in years past, the life cycle cost analysis (LCCA) of energy conservation opportunities in EEAP studies will be done in accordance with ECIP Guidance. We are still using the ECIP Guidance dated 10 Jan 1994, however, the present-worth discount factors that we must use have been updated. The latest present-worth discount factors can be found in the annual supplement to NIST Handbook 135, published by the National Institutes of Standards and Technology. These factors should be incorporated into LCCID soon. Studies which are in progress, and for which LCCAs have already been performed using FY95 present-worth discount factors or the FY95 version of LCCID, do not have to be revised for the new present-worth discount factors. Studies which are in progress, and for which LCCAs have not yet been performed, should use the latest present-worth discount factors. New studies must use the latest factors. When updated ECIP Guidance is received, it will be forwarded to everyone participating in the program.

All districts should be on the distribution list for annual up dates of NISTR 85-3273. This publication is provided free of charge to government offices. Order by title:

Energy Prices and Discount Factors for Life Cycle Cost Analysis,
National Institute of Standards and Technology
NISTR 85-3273-8 (Rev 10/94).

Order from: Advanced Sciences, Inc.
1525 Wilson Blvd, Suite 1200
Arlington, VA 22209-9998

Telephone: (703) 243-4900

The latest version of LCCID may be obtained by calling the BLAST Support Office at the University of Illinois. Just call 1-800-UI-BLAST. If the new version is not yet available, ask to be placed on the list to receive the updated version when it becomes available.

6. A copy of the latest COST GROWTH FACTORS, which are used to project costs for programming documentation, is attached.

COST GROWTH FACTORS
ARMY AND AIR FORCE (AF) CONSTRUCTION PROGRAM

EFF.DATE: ARMY 13 FEB 95
AF 1 MAR 95

DATE	ARMY	AF	DATE	ARMY	AF	DATE	ARMY	AF
JAN 94	1886	910	JUN 97	2075	1000	NOV 00	2300	1106
FEB 94	1888	912	JUL 97	2081	1002	DEC 00	2305	1109
MAR 94	1891	913	AUG 97	2087	1005	JAN 01	2311	1112
APR 94	1893	915	SEP 97	2093	1007	FEB 01	2314	1115
MAY 94	1898	916	OCT 97	2099	1010	MAR 01	2318	1117
JUN 94	1903	918	NOV 97	2104	1012	APR 01	2321	1120
JUL 94	1908	920	DEC 97	2110	1015	MAY 01	2328	1123
AUG 94	1913	922	JAN 98	2115	1017	JUN 01	2335	1126
SEP 94	1918	924	FEB 98	2118	1020	JUL 01	2342	[illegible]
OCT 94	1923	926	MAR 98	2122	1022	AUG 01	2349	[illegible]
NOV 94	1928	928	APR 98	2125	1025	SEP 01	2356	[illegible]
DEC 94	1932	930	MAY 98	2131	1027	OCT 01	2363	[illegible]
JAN 95	1937	932	JUN 98	2137	1030	NOV 01		1139
FEB 92	1940	934	JUL 98	2143	1032	DEC 01		[illegible]
MAR 95	1942	936	AUG 98	2149	1035	JAN 02		1145
APR 95	1945	938	SEP 98	2156	1037	FEB 02		1148
MAY 95	1951	940	OCT 98	2162	1040	MAR 02		1150
JUN 95	1956	943	NOV 98	2168	1042	APR 02		1153
JUL 95	1962	945	DEC 98	2173	1045	MAY 02		[illegible]
AUG 95	1968	947	JAN 99	2179	1048	JUN 02		1159
SEP 95	1973	949	FEB 99	2182	1050	JUL 02		1161
OCT 95	1979	952	MAR 99	2185	1053	AUG 02		1164
NOV 95	1984	954	APR 99	2188	1055	SEP 02		1167
DEC 95	1989	956	MAY 99	2195	1058	OCT 02		1170
JAN 96	1994	959	JUN 99	2201	1061	NOV 02		1173
FEB 96	1997	961	JUL 99	2208	1063	DEC 02		1176
MAR 96	2000	963	AUG 99	2214	1066	JAN 03		1179
APR 96	2003	966	SEP 99	2221	1068	FEB 03		1182
MAY 96	2009	968	OCT 99	2227	1071	MAR 03		1185
JUN 96	2015	971	NOV 99	2233	1074	APR 03		1188
JUL 96	2021	973	DEC 99	2238	1076	MAY 03		1191
AUG 96	2027	975	JAN 00	2244	1079	JUN 03		1194
SEP 96	2032	978	FEB 00	2247	1082	JUL 03		1197
OCT 96	2038	980	MAR 00	2251	1084	AUG 03		1200
NOV 96	2043	983	APR 00	2254	1087	SEP 03		1203
DEC 96	2048	985	MAY 00	2257	1090	OCT 03		1206
JAN 97	2053	987	JUN 00	2271	1093	NOV 03		1209
FEB 97	2056	990	JUL 00	2274	1095	DEC 03		1212
MAR 97	2060	992	AUG 00	2281	1098	JAN 04		1215
APR 97	2063	995	SEP 00	2287	1101	FEB 04		1218
MAY 97	2069	997	OCT 00	2294	1104	MAR 04		1221

EXAMPLES: ARMY: Midpoint of Construction = Oct 97 = 2099 = 1.079 = 7.9%
Midpoint of Estimate Apr 95 1945

AIR FORCE: Midpoint of Construction = Sep 96 = 978 = 1.065 = 6.5%
Date of Estimate Jun 94 918

NOTE: ARMY - Use 3.0% per FY for projections beyond FY 2001.

Figure 4

KELLER & GANNON
Engineers & Architects
Quality Services Since 1941

30 January 1996

Both places – TIME SENT: 10:51
PROJECT No.:
ORIGINAL: /FILE
COPY:

MINUTES OF MEETING

AT: Directorate of Public Works, Building 384
Fort Irwin NTC, CA

ON: 25 January 1996

SUBJECT: EEAP FY96, Water Conservation & Leak Detection Study
Fort Irwin NTC, CA

ATTACHMENTS:
(1) Ft. Irwin Water Well Report for December 1995, 9 January 1996, Dyncorp
(2) Ft. Irwin Reverse Osmosis Water Treatment Report for December 1995, 9 January 1996, DynCorp
(3) FORSCOM DCSPIM Engineer Division Telephone List
(4) Domestic Water System Drawings, 1"=200', Approx. Half-Size, 7 Sheets
(5) RO Water System Drawings, 1" = 200', Approx. Half-Size 5 Sheets
(6) Defluoridation Plant, Process and Instrumentation Diagram
(7) Fort Irwin Integrated Resource Assessment, Vol. 3: Site-Wide Energy Project Identification for Buildings and Facilities, Battelle Pacific NW Laboratory, February 1995

THOSE PRESENT:

Name	Affiliation	Telephone No.
Rene Quinones	DPW, Ft. Irwin	619-380-5048 fax 619-380-5293
Alex Azares	CESPKED-M (Army ISS)	916-557-5126
Walt E. Young (Part time)	DPW, Ft. Irwin	619-380-3518
Blair I. Horst	Keller & Gannon	415-621-1199
Richard C. Lennig	Keller & Gannon	415-621-1199

1. The purpose of the meeting was scope definition and a site visit for the subject projects. Information obtained is summarized in the following paragraphs.

2. The study should include some leak investigations in the Main Post (Cantonment) area plus development of a water leak detection system. MCA projects have already been programmed to renovate water distribution in the housing areas. Most water mains are PVC (all new construction) or asbestos cement, with the last major project occurring in 1967. A few steel mains dating from 1952 still remain.

3. There are two water distribution systems serving Ft. Irwin: (a) a "domestic" or "potable" water system containing high levels of fluoride with mains pressurized to 150-180 psig and PRVs at all buildings to reduce pressure below 80 psig and (b) a reverse osmosis (RO) system containing defluoridized water. The troops may drink the high-fluoride domestic water. The RO water is distributed to Main Post drinking fountains, dining facilities, the ice plant and the TASE photo shop. (The current TASE requirement for 5,000 gallons per day of RO water will be eliminated when the shop is converted to computer-generated graphics.) The water supply system contains 3 booster pumps, 75 to 100HP, that pumps 24 hours per day during peak demand periods.

4. Water, as well as other utility, demand and consumption levels increase dramatically during the 12 yearly training exercises. When the troops return to the Post from the field, the population increases from 4,000 to 8,000.

5. Records of water production from flow meters at wells and records of the RO plant output are available. Individual building water meters are not provided, other than at AAFES facilities. Temporary metering using ultrasonic flow sensors or, possibly, installation of paddlewheel-type flow devices will probably be required during the study to obtain flow distribution data. Records of flows to the sewage treatment plant are available: approximately 1.2 million gallons per day of which 100,000 gallons is brine from the RO plant.

6. The study should include water/energy conservation at the ice plant. The plant was designed for 40 tons/day, actually produces only 28 tons/day, and the total demand for ice during the summer exercise periods is 80 tons/day. The cause of the lower-than-design output is the high temperature of the feed water: 80 to 88 degrees F. The study should evaluate a project to pre-cool the feed water using waste "snow" from the ice-

making process. Since pre-cooling is only needed during hot daytime periods, photovoltaic modules could be used to power a circulating pump. Overflow of melted "snow" would be used for irrigating plantings.

7. It was reported that the Fire Department performs annual dynamic flow tests at all hydrants.

8. The chiller study should consider interconnecting chillers in Buildings 253 and 263 and adding thermal energy storage. Building 253 contains two 250-ton water cooled R-11 chillers and Building 263 contains one 350-ton water cooled R-134a chiller.

9. It was reported that Ft. Irwin intends to purchase wheeled power by 1999, thus considerably reducing electricity demand from the relatively high rates currently paid to Southern California Edison (SCE). This expected rate reduction should be factored into the life cycle cost analyses. The contact at SCE is:

Wayne F. Hofeldt
Senior Energy Service Representative
6999 Old Woman Springs Road
Yucca Valley, CA 92284
619-369-5425
619-369-5423 fax

10. It was reported that numerous irrigation water leaks are caused by coyotes digging at sprinkler heads, with water pressure blowing off the damaged plastic fittings.

11. The following deliverables will be required: interim report, presentation/review meeting at Ft. Irwin, final report.

Richard C. Lennig

cc (without Attachments): Mr. Alex Azares, CESPKED-M (Army/ISS)
Mr. Rene Quinones, DPW Ft. Irwin, 619-380-5293 fax

Post-It™ brand fax transmittal memo 7671	# of pages ▸ 3
To LARRY GITTINGS	From R. C. LENNIG
Co. CESPK-ED-M	Co. KELLER & GANNON
Dept.	Phone #
Fax # 916-557-7850	Fax #

KELLER & GANNON
Quality Services Since 1941

10 April 1997

MINUTES OF MEETING

AT: Directorate of Public Works, Building 384 Conference Room, Fort Irwin, CA

ON: 3 April 1997

SUBJECT: Contract No. DACA05-C-92-0155
Water Conservation & Leak Detection Study
Fort Irwin, CA

ATTACHMENTS:
(1) Review Comments from CESAM-EN-DM (Anthony Battaglia), HQ FORSCOM (Naresh Kapur) and CECPW-ES (Jane Anderson)
(2) Responses to Review Comments, CESPK Project No. 351

THOSE PRESENT:

Name	Affiliation	Telephone No.
Larry S. Gittings	CESPK-ED-M (Army ISS)	916-557-7215
Anthony W. Battaglia	Mobile District, Corps of Engineers	334-690-2618 334-694-4057 fax
Rene Quinones	Planning, Fort Irwin DPW	760-380-5048 760-380-5293 fax
Walt Young	Fort Irwin DPW	760-380-3578
Jane Anderson	U.S. Army Center for Public Works, CECPW-ES	703-806-5214 703-806-5216 fax
Blair I. Horst	Keller & Gannon	415-621-1199
Richard C. Lennig	Keller & Gannon	415-621-1199

1. The purpose of the meeting was to present the results of the Interim Report and to discuss review comments and A/E responses.

2. The responses to review comments provided by the A/E (Attachment (2)) were accepted subject to the corrections and clarifications in the following paragraphs:

1453 Mission Street, San Francisco, California 94103
Phone: (415) 621-1199 FAX: (415) 864-3681
Mail: P.O. Box 422430, San Francisco, CA 94142-2430

3. Mr. Quinones reported that the current Southern California Edison Co. electric power rate structure will remain in force until 31 December 2001, at which time Fort Irwin may shop for power in the deregulated marketplace.

4. Current base electricity rates were accepted as appropriate for use in life cycle cost analyses. Information on base electricity usage and demand levels should be added to Appendix D. (Reference Battaglia comment 2.)

5. Figure 3-5 should be revised to include Well 2A connected to the domestic system through a normally-closed valve.

6. The problem of the increased temperature of water in the million gallon underground tank may be solved by a project and operational changes recently implemented by Fort Irwin DPW: (a) installation of a new 6-inch line from the two million gallon storage tanks (JP-2 and JP-3) that provides gravity flow of cold water to flush out the tank and (b) allowing the water level in the tank to fall lower prior to resuming pumping which allows the hot water to flow past the pumped water well entry points into the supply line from the underground storage tank. The above modifications are expected to reduce mining of the Irwin Basin and, thus, reverse the increasing of total dissolved solids (TDS) and nitrate migration from the sewage treatment area to the well locations.

7. The tertiary roads in the family housing areas are not adequate to withstand the weight of a full water truck; therefore, RO flush water cannot be reclaimed in these areas. Also, a backflow preventer assembly should be used on the flush lines.

8. Visiting troops fill water trucks at the Bicycle Lake booster pumping station. It was suggested that metering be provided and records kept of this water expenditure. (Reference Kapur comment 13a.)

9. It was decided to use 25% of the unit average labor cost of the water systems to approximate the avoided cost of labor from outside sources to provide services that in-house water maintenance workers would normally perform. (Reference Kapur comment 16b.)

10. Ice is necessary to the mission at Fort Irwin because it makes the water that is

required for relief from the high heat (115 degrees F in the shade during summer exercises) more palatable. Ice also assists in lowering body temperatures of soldiers during periods of extreme heat. (Reference Kapur comment 17.)

11. It was noted that phased pipe replacements should be coordinated with planned road widening projects.

12. Irrigation of the golf course has been stopped because nitrates in the irrigation water migrated down to the water table, toward the Irwin Basin wells. With the changes now in effect, the Irwin Basin wells will be pumped less, to be offset by additional mining of the Langford and Bicycle Basins. (Reference Anderson comment 2.)

13. The RO water distribution system is flushed every three *months* rather than every every three *weeks* as reported in the study. (Reference Anderson comment 7.)

14. The project to provide additional domestic water storage to allow well pump load shifting should be revised to include the additional cost of installing the new tank on higher ground at the Ammunition Storage Area.

15. Programming documents to be submitted with the Final Report, subject to the life-cycle cost analysis reevaluations, should be as follows:

    - Additional domestic system water storage & well pump load shifting: ECIP program DD Form 1391

    - Ice plant water conservation & pre-cooling retrofit: Form 4283 (Work Request)

    - Reclamation of domestic and RO system flush and hydrant test water: Form 4283 (Work Request)

    - Underground reservoir repair & 220-unit family housing heat pump cooling modification: No programming document required.

Richard C. Lennig

Richard C. Lennig

RCL: rcl/16-403-21

F:\PROJ\1640321\ENGR\MN04-10

MOBILE DISTRICT PROJECT REVIEW COMMENTS:	DATE: 19 March 1997	Page 1 of 1
TO: Larry Gittings, CESPK-ED-M USAED, Sacramento	FROM: Anthony W. Battaglia, CESAM-EN-DM Phone: (334) 690-2618 FAX: (334) 694-4057	

PROJECT/FY: EEAP FY96 Water Conservation Study

LOCATION: Fort Irwin National Training Center, CA

TYPE REVIEW: Interim Submittal

NO.	Page/Par	COMMENT	Response to Comment
1.	General	Overall, this report looks good. It is up to the high standards we have come to expect from Keller & Gannon. There are some editorial comments; but Comment No. 2 is the one which is of greatest concern to me.	
2.	General	This has to do with the calculation of the marginal energy savings rates. On page 4-1, par 4.1.2 describes the incremental sales rate (ISR) rider. It states that there are base levels of consumption and demand which are billed at a fixed monthly amount; and that Fort Irwin is billed for these levels whether they use them or not. The actual values of those base levels are not stated in the text nor shown in the graphs of Appendix D (Figures D-2 & D-3). One cannot tell from the text or the graphs if Fort Irwin actually exceeds the base levels. If Fort Irwin does not exceed the base levels of consumption and demand, then the energy and demand savings resulting from the projects investigated in this report would have no impact on the overall utility bill. I would be very surprised if this were the case. However, if Fort Irwin does exceed the base levels of consumption and demand, wouldn't the marginal energy savings rates have to be based on the incremental rates rather than the base rates? Please discuss and make corrections where necessary.	
3.	Pg 3-4	Please complete the last sentence in the first paragraph.	
4.	Pg 4-3	Par 4.1.3: Insert missing word, "is" in next-to-last line.	
5.	Pg 4-6	Par 4.2.5: Please clarify an apparent contradiction. One sentence states, "The cooling tower system will utilize more energy than the current system, and will require maintenance." In the next paragraph, it states, "Energy savings include 36.5kW of demand savings and 12,000 kWh per year of electricity usage for annual energy cost savings of $6,550." If it uses more energy, how can it have 12,000 kWh per year of energy savings?	
6.	Pg 4-8	Par 4.3.2: Complete the last sentence.	
7.	App D	Table of Contents: Add the word "Water" to the title of Appendix D-4.	
8.	App D	Figure D-2, pg D-8, and Figure D-3, pg D-9: See Comment 2, above.	
9.	App E	Pg E-2: Please clarify: "Static pressure in Supply Pipe: 60 psig, assumed average of 80 psig supply and T-140" What is T-140?.	
		END OF COMMENTS	

ATTACHMENT (1)

FORSCOM COMMENTS FOR EEAP STUDY-INTERIM SUBMITTAL

WATER CONSERVATION AND LEAK DETECTION STUDY, FT IRWIN, CA

1. GENERAL. The interim report is well organized. Keller and Gannon deserve to be recognized for this. We expect the final report to be outstanding.
2. GENERAL. Suggest AE prepare a 2-3 page Information Paper about the study. This can be used to brief the installation commander and non-engineer type managers. Suggested headings for this are: Background; Scope; Recommended projects; Operation/Maintenance changes; Remarks.
3. Para 2.3.3 Final Report. How do we handle any changes needed to the final report if certain items are not satisfactory? Consider having a prefinal submittal. If no change is required, call it a Final submission.
4. Para 3.4. Second para indictes 31.2 million gallons of Brine waste goes to sewer every year. What is the range of concentration of salt and other solids in this waste waste stream? Any suggested alternative to the current practice?
5. Para 3.5. First para, last sentence, rewrite this for a better understanding.
6. Para 4.2.1. Clearly state the estimated water leakage attributed to domestic water and that from Reverse Osmosis plant supply. Do it likewise in appendix B.
7. Para 4.2.5. Have we considered other alternatives to repairing the tank. How about the tank replacement option? See how it pans out.
8. Pg 4-7. Request AE follow up on Vehicle wash racks and Reverse Osmosis plant improvements for LCCA.
9. Pg 4-9, second para. 4,284,882 gallons of flush water from R-O plant is lost. Is this flush water drinkable? Can it be captured and reused by a method other than water tank? If so, let us talk about it.
10. Para 5.1. Pl explain why RO water temperature rises from 71 to 88 degrees F?
11. Appendix.A.pg5. Mr. Alex Azares address should be replaced with that of Mr. Larry Giddings address.

12..ANNEX A to Appendix A.

a. Para 2.4 says," The AE may be aware of other WCOs not included in the Annex A or Annex B that will produce water, energy, manpower, or dollar savings. These should be evaluated the same as listed WCOs. In view of this, the traditional WCOs related to the toilet tanks and water faucets should be included. CPW rep can provide additional info if needed.
b. AE may want to comment on para 2.7 about development of unit cost of water.
c. Para 5.1 ECIP Projects. The lower limit for ECIP projects is $500K instead of $300K. AFH projects are eligible for ECIP funding.
d. Para 7.1. Were there any previous studies which we can relate to the current study? In what part of the report is it addressed?
e. para 7.5. AE should obtain this info from DPW rep and include in the report.

f. Para 7.6.2. When is prefinal report expected?

13. Annex B to Appendix A.

a. Para 2. Water and other Utility demand and consumption level increase drametically during twelve yearly trg exercises. If possible, obtain and modify SOPs related to water conservation for inclusion in the report.

b. Para 4e(4). A copy of the latest ECIP guidance is available from Mr. Kapur if needed.

14. Annex D, Appendix A.

a. Refer to para 5 of INFORMATION FOR PARTICIPANTS IN THE FY96 EEAP. In para 5, The information about "Energy Prices and Discount Factors for Life Cycle Cost Analysis" is now available by calling 1-800-DOE-EREC. The address and tel # mentioned in this para is no longer valid.

b. Minutes of the meeting, dtd 30 Jan 1996.

- Para 3. The current TASE requirements of 5000 gallons per day of RO water will be eliminated when the shop is converted to computer generated graphics. What is the status? What needs to be done to close the loop?
- Para 6, 7, 8,and 9. Discuss these items.

15. Appendix C, pg C-20. For a better understanding, request AE provide a brief writeup on RO operation and incorporate these vital statistics in the writeup.

16. Appendix D.

a. The electricity rate structure is still confusing. AE is requested to demonstrate how the bill is impacted due to varying rates of different categories. How can Ft Irwin use the available info to reduce its utility bill? We do't mind if the Utility rep is invited to explain. This can be coordinatd prior to the mtg on 3 Apr 97.

b. Pg D-4 thru D-6. Some of the O&M costs like Operators/Supervision wages are valid expenses to calculate unit cost of producing water. When we save water by any means, the savings associated with the labor can not be realized in the real life situation. Pl comment.

17. Appenxix E. Pg E-36. If possible, add a brief para as to when and why the ice plant came into being? Is supplying ice to soldiers a part of the mission/training requirements?

18. Appendix F. Request AE provide a paragraph to cover the subject matter of Phased Pipe Replacement. The tabulated info does not clarify what is going on?

Naresh Kapur
HQ FORSCOM
404-464-5327
FAX -7751

Document Title: Water Conservation & Leak Detection Study, Ft. Irwin, California

Reviewer: J. Anderson (CECPW-ES) **Date Returned:** 26 Mar 97

#	¶	line	Comments
1	3.4		Both Domestic Water and RO Water Supply Sections are listed as 3.4.
2	3.5		What are the 1992 RWQC requirements which necessitate discontinuing the current golf course irrigation practice? What is the "nuisance condition?" Please provide additional background information.
3	Fig 3-2		Is the cause of the Dec 93 spike in water production known?
4	Fig 3-3		Is the cause of the high RO water production for Oct and Dec 94 known?
5	4.2.6		2nd paragraph under Reverse Osmosis Plant states that an additional 15.0 MGY could be produced and used for new service connections. Is there an anticipated need for additional RO water?
6	4.3.2		Insert "be replaced" after "industrial area"
7	4.3.3		Last paragraph: What is the purpose of flushing every three weeks? Is this necessary for water quality? Have any potential options, such as elimination of dead-ends, for reducing flushing been investigated?
8	5.3		What is the cost for the ice plant to produce ice (i.e., how does it compare to the purchase price)?
9	General		No listing of WCO's considered and rejected is provided. Were any other water-saving methods investigated?
10	APPX. D		Water costs used in economic analyses should be marginal costs (i.e., items such as labor, and maintenance/safety equipment, which will not be significantly impacted by the water conservation measures considered, should not be included).
11	APPX E	E-1	If pressure is to be measured at the top of a water truck, shouldn't the difference in elevation be accounted for?
12	APPX E		As noted above, marginal water costs should be used in economic analyses.
13	APPX E	E-29 - 35	What is the quality of the RO reject water (brine)? Could this also be used for irrigation, or other non-potable purposes?
14	APPX E	E-41- -43	If possible, it may be prudent to provide additional excess capacity for waste water/ice.

15	APPX E	E-44 - 49	Please clarify how the new arrangement will operate. What will be the source of the cooling tower water? It does not appear that the cost of water lost from the cooling tower (evaporation and bleed-off), or the cost of treating the make-up water, has been considered in the economic analysis. Will the water be drawn from the RO or domestic system? Could flush water from hydrant testing or the RO plant be used?
16	General		Several of the recommended projects are for capturing water to be used for irrigation. What storage is available if the water cannot be immediately used for irrigation? There are also projects being considered for reducing Ft. Irwin's irrigation needs by 90%, and for treating domestic wastewater to be used for irrigation. Will there be enough demand for irrigation water to accommodate all these projects? Have other options for using non-potable water (such as cooling tower make-up) been considered?

Anthony W. Battaglia, CESAM-EN-DM COMMENTS 3/19/97

1. Noted. Thank you.
2. Agree. Base levels of consumption and demand are exceeded in all months; however, the energy pricing used is felt to more adequately reflect the future power supply costs than does the present incremental rate structure. This is due to a planned change to wheeled power in the future and due to the probability that the electric rate structure will change radically when the current contract expires.
3. Done. See page 3-4.
4. Done. The word "is" is inserted.
5. Agree. The apparent conflicting statements will be clarified. The cooling tower <u>will</u> use power not currently needed, but will save energy presently lost to replace leakage.
6. Done. The sentence is completed as requested.
7. Done. The word "water" is added as stated.
8. Noted. See response to comment No. 2, above.
9. Agree. The pressure of 60 psig is conservative, and is used to avoid over estimating water savings. An explanation will be added to the calculations.

FORSCOM COMMENTS (Naresh Kapur) 3/25/97

1. Noted. Thank you.
2. Agree. An Executive Summary will be provided with the Final Report that reflects corrections and revisions to the study as a result of the review conference as well as a summary of programming documentation. We believe that submitting an "Information Paper" to the installation commander at this point in the study effort is premature.
3. Noted. Please refer to Statement of Work paragraph 7.6.2; procedures for correcting submittals are addressed there. The contract does not require a Pre-Final submittal.
4. Agree. Analysis results of Reverse Osmosis (RO) Plant influent (feed) and product (effluent) are listed below. Analysis results of the brine wastewater were not provided.
   Influent TDS = 518 ppm; Effluent TDS = 73 ppm
   Based on production records, 48% of the feed is converted to RO water. This will produce an brine effluent of at least 936 ppm as calculated below, based on FY 1996 RO Plant records.

ATTACHMENT (2)

Feed	RO Product	Brine Waste
59,482,100	28,814,100	30,668,000 Gallons in FY 1996
518	73	936 ppm TDS

A TDS of almost 1,000 ppm could possibly be used for other purposes. However, as pointed out in the report, the RO Plant is soon to experience a renovation, almost doubling its efficiency. Brine production will decrease; the TDS concentration will, correspondingly, increase. The resulting brine will probably leave salt on any surface it is applied to for irrigation purposes, quickly masking the ground from further percolation. Continues discharge to the sanitary sewer is recommended. This is notwithstanding the expense of a "gray water" system, including piping, storage, pumps and irrigation system retrofits.

5. Agree. The sentence is rewritten.

6. Agree. Although paragraph 4.2.1 clearly states the estimated water leakage in the domestic system and paragraph 4.3.1 clearly states the estimated water leakage in the RO system, if desired, a table summarizing leak data will be inserted in the chapter. Appendix material is provided in support of the text and, as such, need not be revised.

7. Agree. Other options were considered when developing the project. However, the least expensive alternative is to repair the existing tank. Compare, for example, the relative costs of a new 750,000 gallon tank (Appendix E, page E-24) compared to the repair costs for this project. This comparison will be added to the project description in the text.

8. Disagree. These projects are programmed and funded. No further consideration is indicated except to integrate their effects on future water consumption.

9. Agree. Other solutions such as providing pump loops were considered, however too many of them would be required to provide a cost effective installation. The project is "operational" because water treatments and installed piping systems are changing. Adding capital improvements to the distribution system may be unneeded if technology changes to make them unneeded.

10. Agree. An explanation is added to the paragraph.

11. Agree. The change will be made. The Interim Submittal was directed to the attention of Mr. Gittings rather than Mr. Azares at CESPK.

12.a. Disagree. The project SOW addresses the distribution systems specifically. Point-of-use surveys were specifically excluded from the SOW.

12.b. Agree. Unit water costs were developed and applied to LCCA's on a component basis. Double counting of savings is not done.

12.c. Noted. Project bundling will be accomplished at the review meeting.

12.d. Agree. No previous studies of this nature were done at Fort Irwin. This will be explained.

12.e Noted. Project bundling will be accomplished at the review meeting.

12.f Noted. The Final Report will be submitted 30 days from the review conference, or 5 May 1997. There is no prefinal report submittal.

13.a. Agree. Procedural changes are not relevant if systems are installed properly, e.g., extra storage is recommended to allow pumping to take place only during non-peak electrical rate periods. This will be explained further.

13.b. Noted. Thank you, the latest guidance arrived with the contract. If there is more recent guidance available, please provide it to us.

14.a. Noted.

14.b. Noted. The TASE activity must complete the technology change. This is programmed and funded.

14.b. Agree. Para 6: Ice plant precooling is addressed in Section 5.0 of the report.

Para 7: Fire hydrant testing water reuse is addressed. See para. 4.2.3.

Para 8: A study of chillers and their distribution and operation were specifically excluded from the scope of work.

Para 9: As a result of discussions with Mr. Rene Quinones, Resource Analyst at Fort Irwin DPW, the decision was made to use known current base energy rates in the analyses rather than hypothetical future rates.

15. Agree. A simple explanation of the chart will be provided.

16.a. Agree. Additional clarification of the existing electric power rate structure will be provided, including a summary of base levels of consumption and demand.

16.b. Agree. Analyses will be revisited and explanations provided were labor saving are claimed.

17. Agree. An explanation will be included if provided by Fort Irwin. Justifying facilities is not within the scope of this work.

18. Agree. A paragraph explaining phased pipe replacements will be added to the text. Appended data is provided to support the text. Each appendix need not be a stand-alone document.

CECPW-ES COMMENTS (Jane Anderson) 3/26/97

1. Agree. Section numbering 3.4, 3.5 and 3.6 will be corrected.

2. Agree. A more complete explanation will be requested from Fort Irwin. The requirements are in response to studies or other findings concerning salinity increases in the groundwater due to percolation.

3. Agree. The cause of the 1993 spike in water use is not known specifically, but is probably due to a training exercise or other increased military activity (Desert Storm?).

4. Agree. The cause of the Oct-Dec 1994 spikes in RO water use is not known specifically, but is probably due to a training exercise or other increased military activity (Desert Storm?).

5. Agree. There is probably a future increased demand for RO water due to the construction program at Fort Irwin. Master planners at Fort Irwin will be queried and an explanation provided. The statement points out a resource that could be tapped if future expansion plans include an increased RO water demand.

6. Done. Paragraph 4.3.2 is modified as suggested.

7. Done. Last paragraph of section 4.3.3: please refer to the second paragraph of this section.

8. Agree. The cost of ice to the government is fixed at set contract rates for the next 5-year period regardless if the ice plant operates at capacity or not. The government does pay for electric power, thus the proposed retrofit is evaluated as it affects costs to the government for electric power. An explanation will be provided in the text.

9. Agree. The scope of this project was limited to distribution system water conservation. The WCO's will be listed with explanations in the text.

10. Agree. WCO analyses will be revised to take out "base-level" costs, where appropriate.

11. Agree. The specific method of a modified test is not addressed in this study, but the pressure readings should, indeed, account for differences in elevation.

12. Agree. See response No. 10, above.

13. Agree. Please refer to the response to Naresh Kapur comment No. 4.

14. Agree. It is not clear if the comment addresses ice plant capacity or wastewater/ice storage capacity. In the first case, this is beyond the scope of the study. In the second case, added capacity would be more expensive and the ice would melt if not needed quickly (in spite of added insulation).

15. Agree. Calculations for this WCO will be revised to include blowdown and drift losses in addition to water treatment costs.

16. Agree. Many potential uses for the flush water exist. Dust control at construction projects and RO flushing water for visiting troops are two possibilities in addition to that of irrigation. Providing storage for flush water would probably be too expensive. There are few opportunities for use of flush water that will not require expensive storage tanks. Few cooling towers are used at Fort Irwin in order to reduce water demands. This is why only very conservative assumptions are used in calculations. There will be a future need for irrigation on school

playing fields and parks at Fort Irwin. The proposed use of treated domestic wastewater for irrigation of public parks and playing fields is questionable; public health concerns may preclude its use in spite of plans to provide disinfection.

APPENDIX B

Leak Survey Report - M.E. Simpson Company

M.E. SIMPSON Co., Inc.

P.O. Box 1995
Valparaiso, IN 46384

800/255-1521
Fax: 219/531-2444

Branch office:
Grayslake, IL

December 19, 1996

Mr. Richard C. Lennig
Vice President
Keller & Gannon
1453 Mission Street
San Francisco, CA 94103

Re: Ft. Irwin NTC, CA Water Conservation & Leak Detection Study. Project # 16-403-21

Dear Mr. Lennig,

M.E. Simpson Company is a professional & technical service company that offers Leak Survey Programs, Large Meter Testing and Repair Programs, Water Main Location, and Valve Exercising, Location and Computer Mapping Programs. These **"Professional Services"** offered by M. E. Simpson Company are designed to aid a utility in reducing unaccounted for water and lost revenue.

M. E. Simpson Company is pleased to submit this report of our leak detection survey for the Ft. Irwin Army Post. This survey addressed the Ft. Irwin water distribution system, consisting of approximately 40 miles of water main. The report contains the results of our investigation that includes the following:

1. A DESCRIPTION OF THE AREA SURVEYED.
2. METHODOLOGY OF THE SURVEY
3. A LIST OF LEAKS AND TYPE OF LEAK LOCATED.
4. GENERAL RECOMMENDATIONS BASED ON OUR INVESTIGATION.

DESCRIPTION OF THE AREA SURVEYED

Approximately 211,200 lineal feet was surveyed as part of the system investigation. This included all fire hydrants, all accessible mainline valves, and 35 services.

METHODOLOGY

M.E. Simpson Company used the **FLUID CONSERVATION SYSTEMS S20** listening device along with the **MP90** preamplifier-transducer system to conduct your survey. Our experienced technicians used these devices as listening equipment to survey the pipeline network. <u>Each hydrant, and accessible valves</u> were used as listening points to identify leaks. Service, b-boxes, (18) were used to keep the listening distances under five hundred feet (500'). **"Pin-Pointing"** of the leak, as well as locating leaks that other methods failed to reveal was done with the **90/90** and or **C2000 LEAK CORRELATORS,** the latest state of the art leak computers. These electronic instruments are microprocessor units that measure the time it takes the sound of the leak to travel from the leak to the point where the leak correlator is connected to the water line. By connecting the leak correlator to the water line at two locations, it will compute the distance from the leak to each connection point thus enabling us to determine the exact leak location. The results of the leak survey, including an estimate of water loss for the leaks identified, is documented in this report.

LEAKAGE LOCATED

All water mains within the project area were surveyed and 17 leaks were located. These leaks have been grouped as follows: Main Line Leak - 2. Service Line Leak - 2. Valve Leak - 2. Hydrant Leak - 7, Other Type Leak - 4. All of these leaks have been verbally reported to your office with there locations. so many have probably been repaired already. Following are the leak locations with an estimated GPD (Gallons Per Day) leakage potential.

Type	Location	SIZE
Main Line	Barstow & Second Street (Dom. #1) see enclosed diagram Not [illegible]	14,400 GPD
Main Line	Barstow Road & Second Street (Dom. #2) see enclosed diagram	28,800 GPD
Service Line	3724 Sicily (R-O #1) see enclosed diagram **Fixed**	14,400 GPD
Service Line	3809 Corregidor (R-O #2) see enclosed diagram **Fixed**	7,200 GPD
Valve	3721 Ardennes (R-O #3) see enclosed diagram	7,200 GPD
Valve (packing)	Avenue B at First Street (Dom. #3) see enclosed diagram	4,320 GPD
Hydrant (visible)	South Loop at Third Avenue (Dom. #4) see enclosed diagram	2,880 GPD
Hydrant	5129 C Rio Hondo Cove (Dom. #5) see enclosed diagram	1,080 GPD
Hydrant	Avenue B at First Street (Dom. #6) see enclosed diagram	1,080 GPD
Hydrant	Building #6030 (Dom. #7) see enclosed diagram	1,080 GPD
Hydrant	Building #6045 (Dom. #8) see enclosed diagram	1,080 GPD
Hydrant	Cambria at Rhineland (Dom. #9) see enclosed diagram	1,080 GPD
Hydrant	Silurian Hills Drive (Dom. #10) see enclosed diagram	1,080 GPD
Other	3732 Appomattox (Dom. #11) see enclosed diagram	360 GPD
Other	Avenue B & Fifth Street (Dom. #12) see enclosed diagram	7,200 GPD

Type	Location	SIZE
Other	Bldgs. # 6017, 6032, 6047, 6057 (Dom. #13) see enclosed diagram	28,800 GPD
Other	Fifth Street- Bldg. S594 (Dom. #14) see enclosed diagram	7,200 GPD
17 Leaks Located	**ESTIMATED LEAKAGE TOTAL**	**129,240 GPD**

LEAK QUANTITIES

Quantifying leaks is difficult because there is not any accurate means of doing so. Pipe material, size of the leak, system pressure, soil material and water table will effect the noise that a leak makes. Small leaks under high system pressure will make more noise than a large leak under low system pressure. However, the above leaks are of sufficient noise levels that the above estimates should be very conservative. Using a production price of $0.50 per thousand gallons for domestic use, these leaks were costing your utility in excess of $50.00 per day or $18,250.00 annually. Your production price of $1.00 per thousand gallons for R-O use were costing your utility in excess of $28.00 per day or $10,512.00 annually. It obvious that this Leak Survey Program has proven to be cost effective. Naturally the main line leaks have the greatest potential for loss followed by service line, valves, and finally hydrants. Once leaks have been repaired, we would recommend that the Utility compare pumping rates before and after. This information will be more meaningful and accurate.

RECOMMENDATIONS

This survey confirms that the Ft. Irwin water distribution system will benefit from this project by a reduction in underground leakage. There is always a concern over the cost effectiveness of leak detection because of the uncertainty of the number of leaks located. However, with your present cost of water and the discovery of these seventeen leaks, the cost of this 1996 leak survey will pay for itself within six months. It only takes a recovery of about 75,000 gallons per day on an annual basis (75,000 gallons per day is only 52 gallons per minute throughout your entire water distribution system) to recover your investment. We would recommend that you conduct a Leak Survey Program every year. This recommendation becomes more critical as your cost of water increases.

Also, during our survey we noticed the large volume of irrigation that is being conducted on the Post. After reviewing procedures and checking consumption estimates for irrigation ,we determined that the Army is using an average of 900,000 gallons a day to irrigate the Post. We would strongly recommend that the practice of irrigating be severely cut back, if not eliminated all together, due to the concern over water usage and availability. Irrigating the Post to create an atmosphere of something other than the desert that it is, is absurd. A majority of the plant life that was being irrigated is not indigenous to the area. With an all out effort to conserve a precious life giving resource, we feel that the elimination of this practice will reduce overall costs to the utility and conserve much needed future drinking water.

We appreciate the cooperation of Mr. Walter Young and his staff who were available to answer our questions during this project. If you have any questions with the information in this report, please do not hesitate to call.

Sincerely Yours,

Michael D. Simpson
Vice President / General Manager

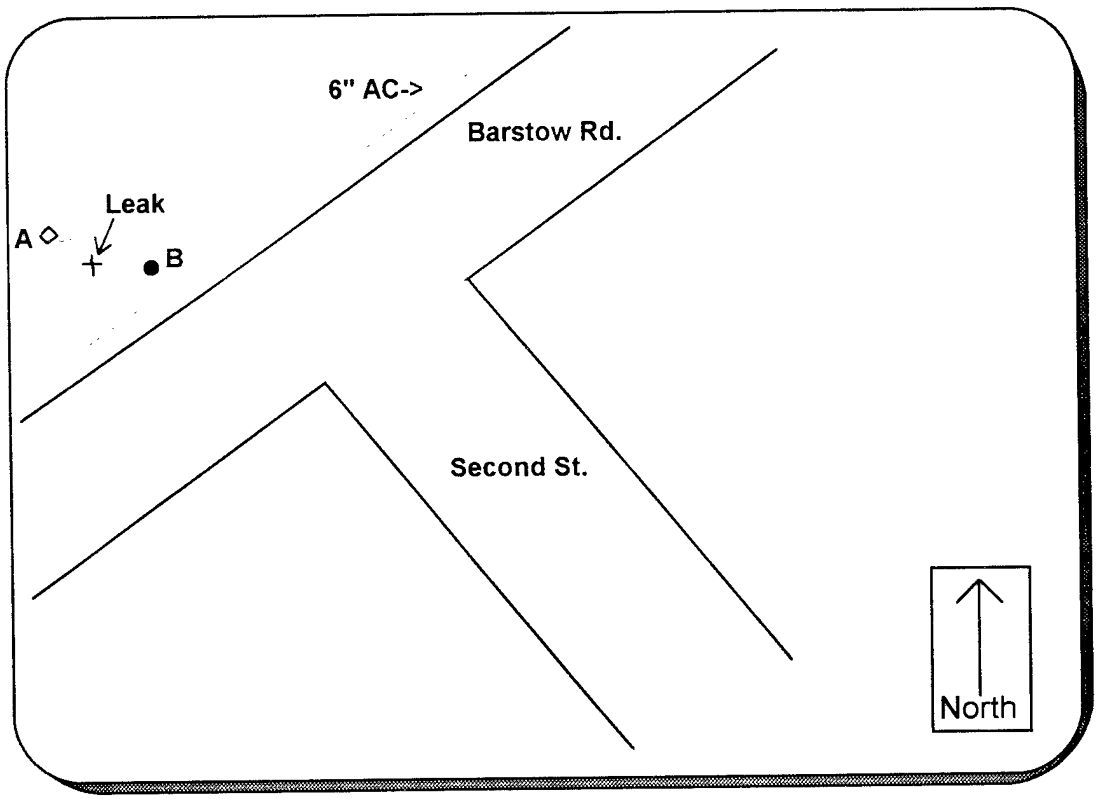
M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA **Time:** Leak Survey

Date: Friday, December 13, 1996 **Tech:** Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance: 72' from A to B

Connection point: A= RPZ

Connection point: B= Hydrant

Connection point:

Connection point:

Leak Location: 22' from A

Comments:

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

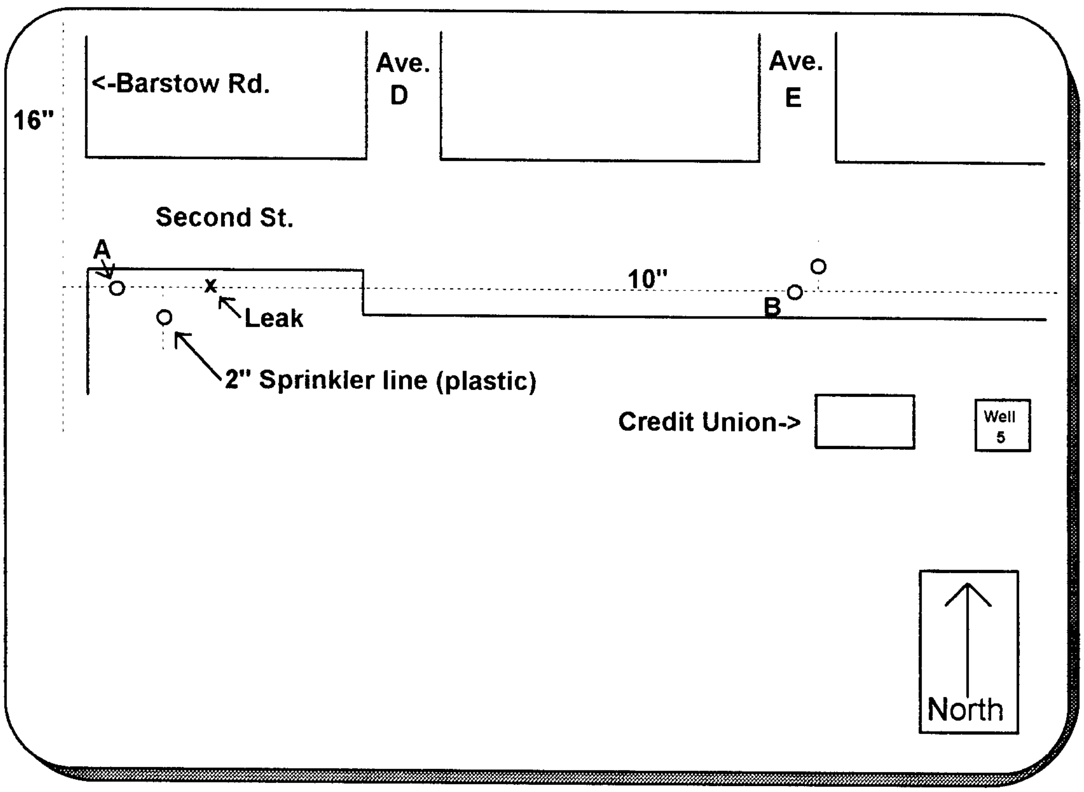
M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA **Time:** Leak Survey

Date: Wednesday, December 11, 1996 **Tech:** Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance: 322' from A to B

Connection point: A= Main line valve on Second St. at Barstow Rd.

Connection point: B= Main line valve on Second St. at Ave. E

Connection point:

Connection point:

Leak Location: 38' from A

Comments:

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

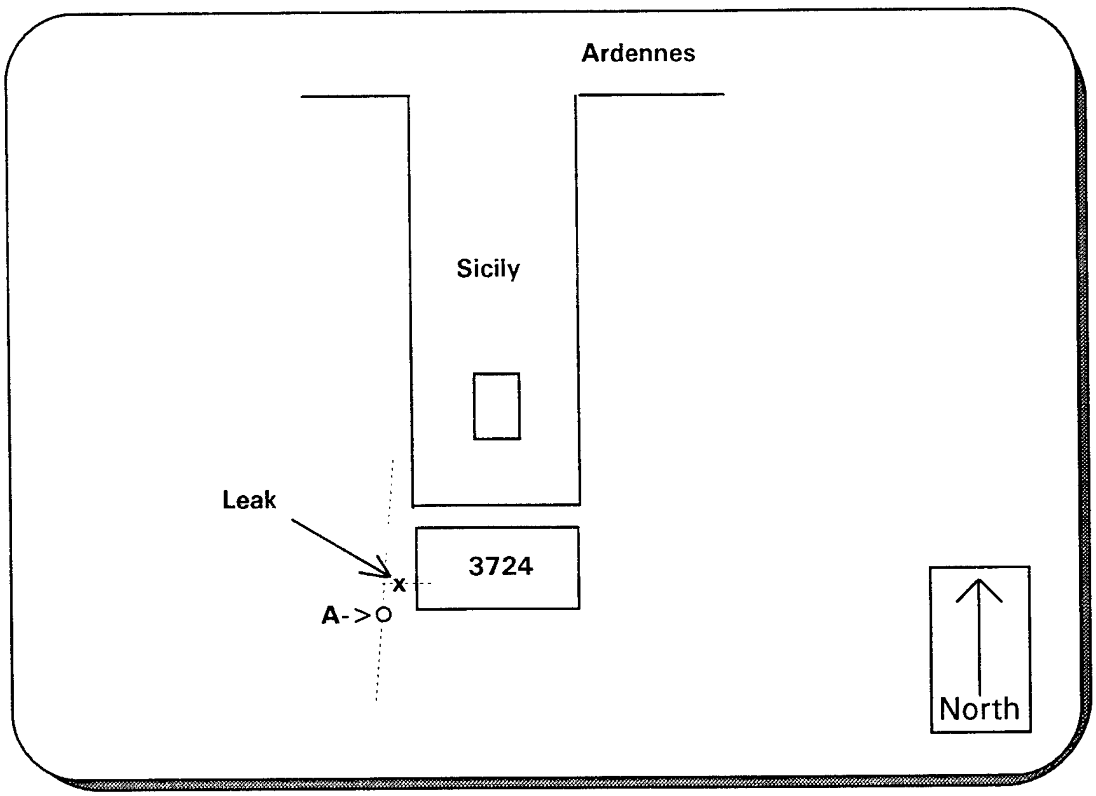
Client: Fort Irwin, CA

Time: Leak Survey

Date: Monday, December 09, 1996

Tech: Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= Valve

Connection point:

Leak Location: 15' from A

Comments: This was a service leak next to the west wall of the house. This leak is fixed. (R-O system)

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

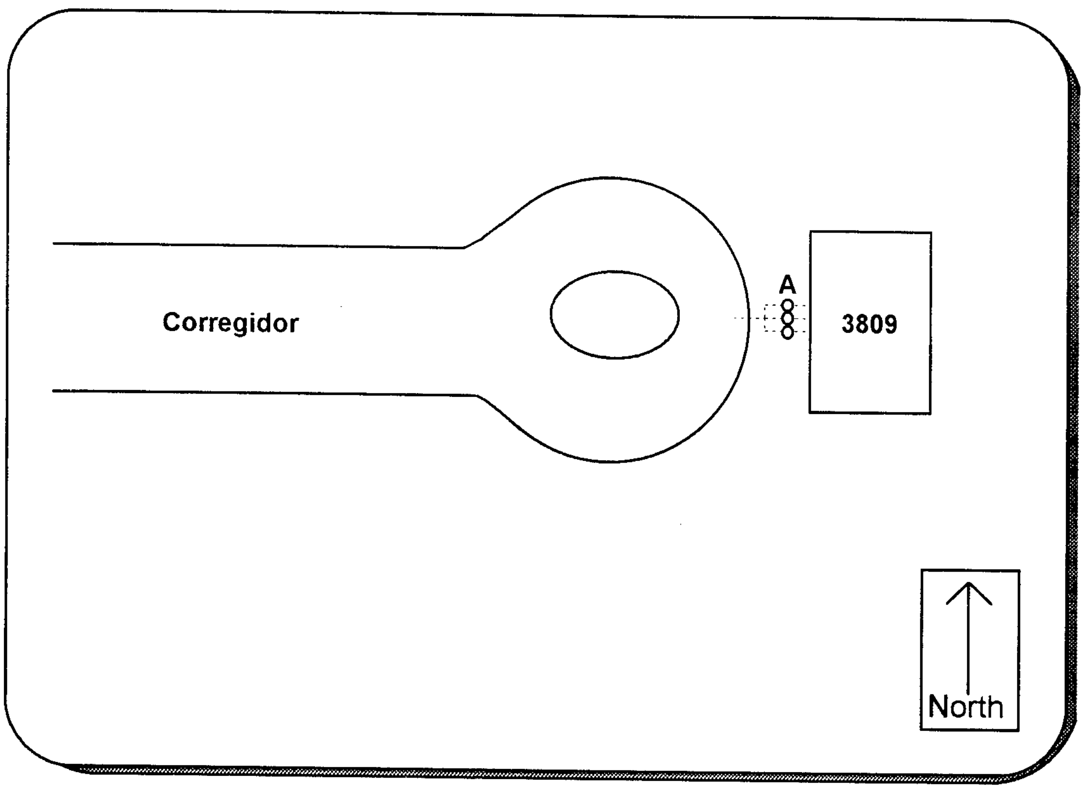
M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA **Time:** Leak Survey

Date: Monday, December 09, 1996 **Tech:** Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= Services to 3809 Corregidor

Connection point:

Connection point:

Connection point:

Leak Location: One of the services at "A" is leaking.

Comments: These services have been dug up and this leak is fixed. (R-O system)

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

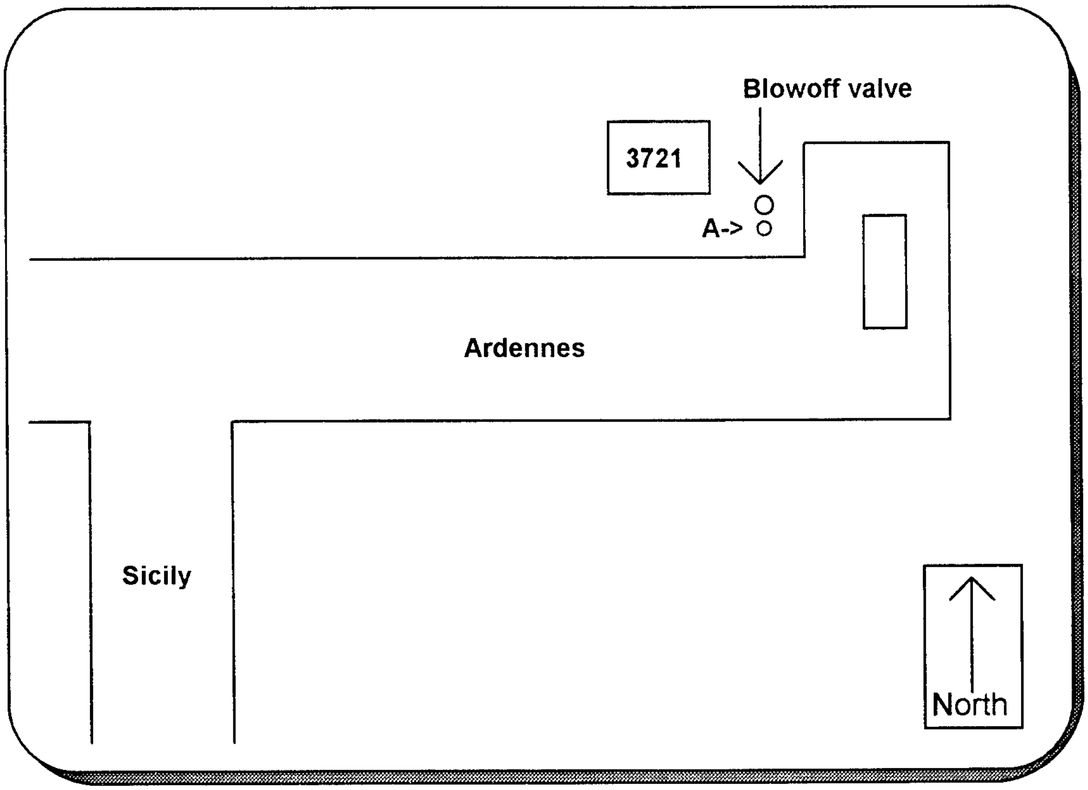
M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA **Time:** Leak Survey

Date: Monday, December 09, 1996 **Tech:** Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= Valve

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: This is a visible valve leak and should be dug & repaired. (R-O system)

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

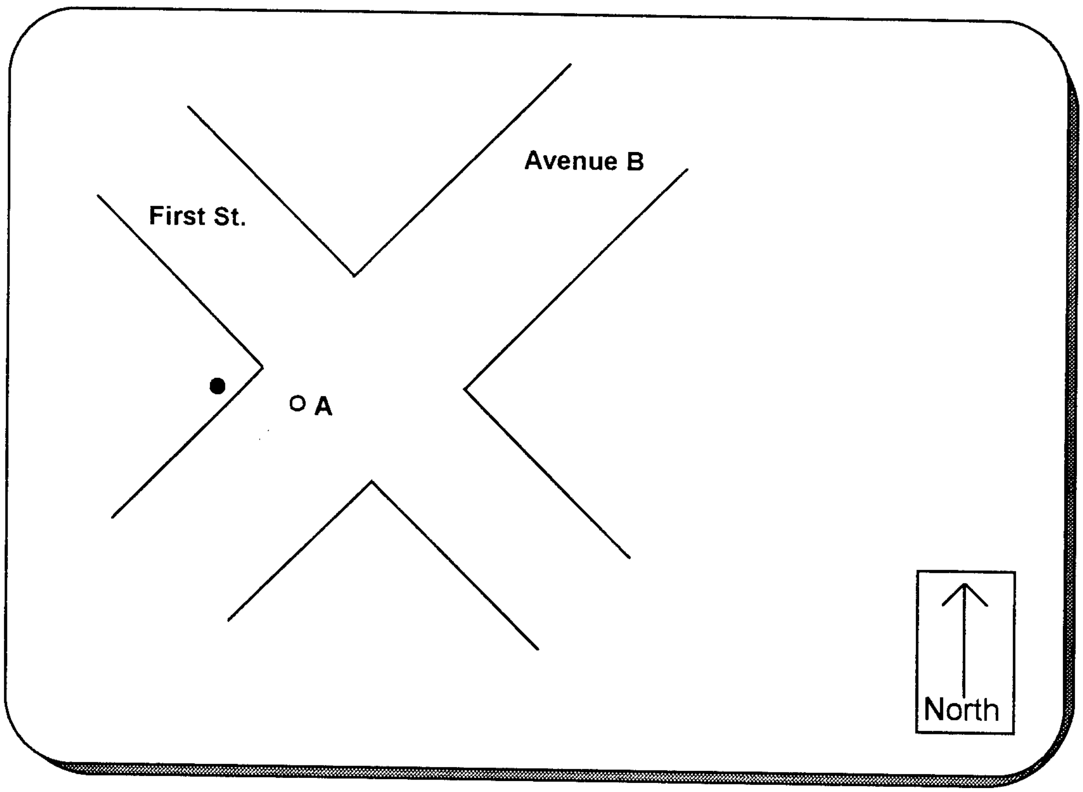
Client: Fort Irwin, CA

Time: Leak Survey

Date: Thursday, December 12, 1996

Tech: Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= Valve

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: This is a packing leak.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

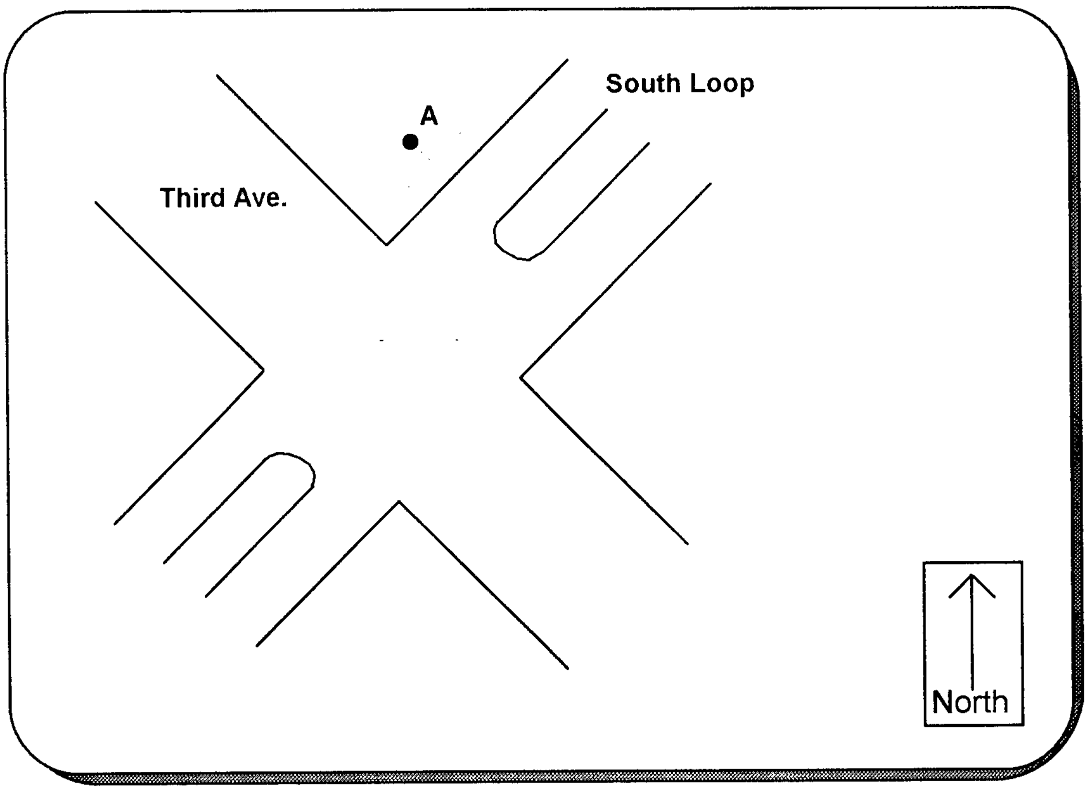
Client: Fort Irwin, CA

Time: Leak Survey

Date: Thursday, December 12, 1996

Tech: Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= Hydrant

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: This is a visible hydrant leak.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

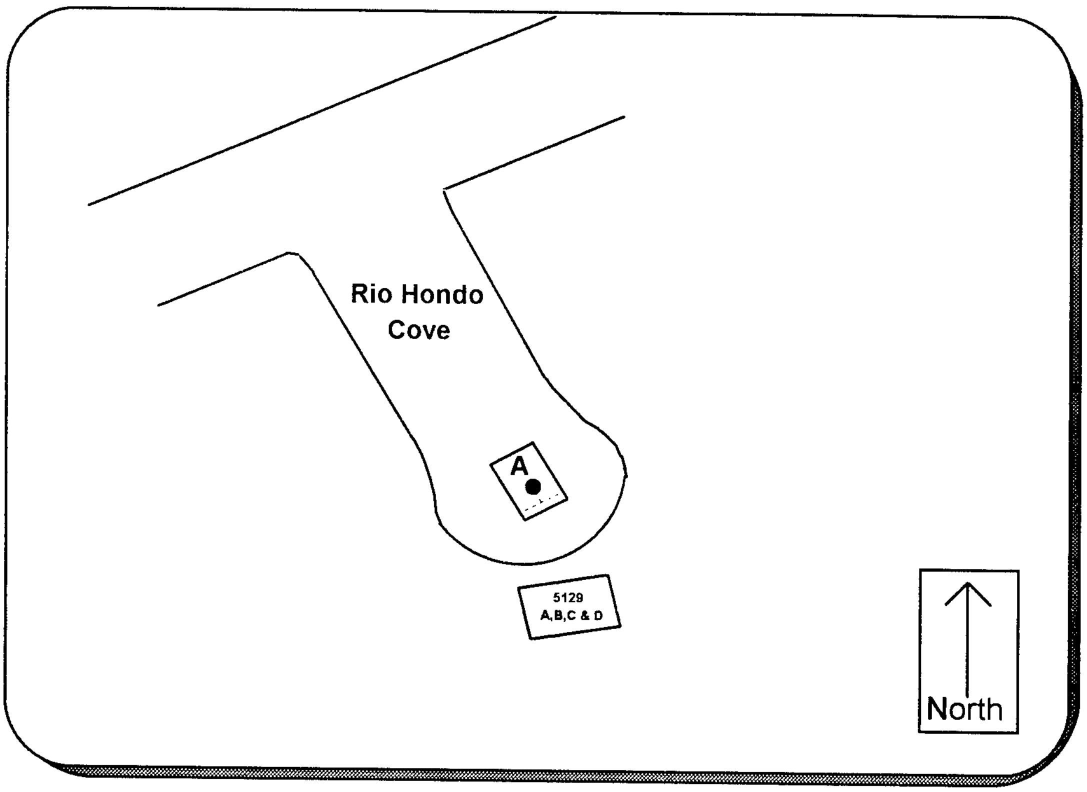
M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA **Time:** Leak Survey

Date: Thursday, December 12, 1996 **Tech:** Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= Hydrant

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: This is a hydrant leak.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

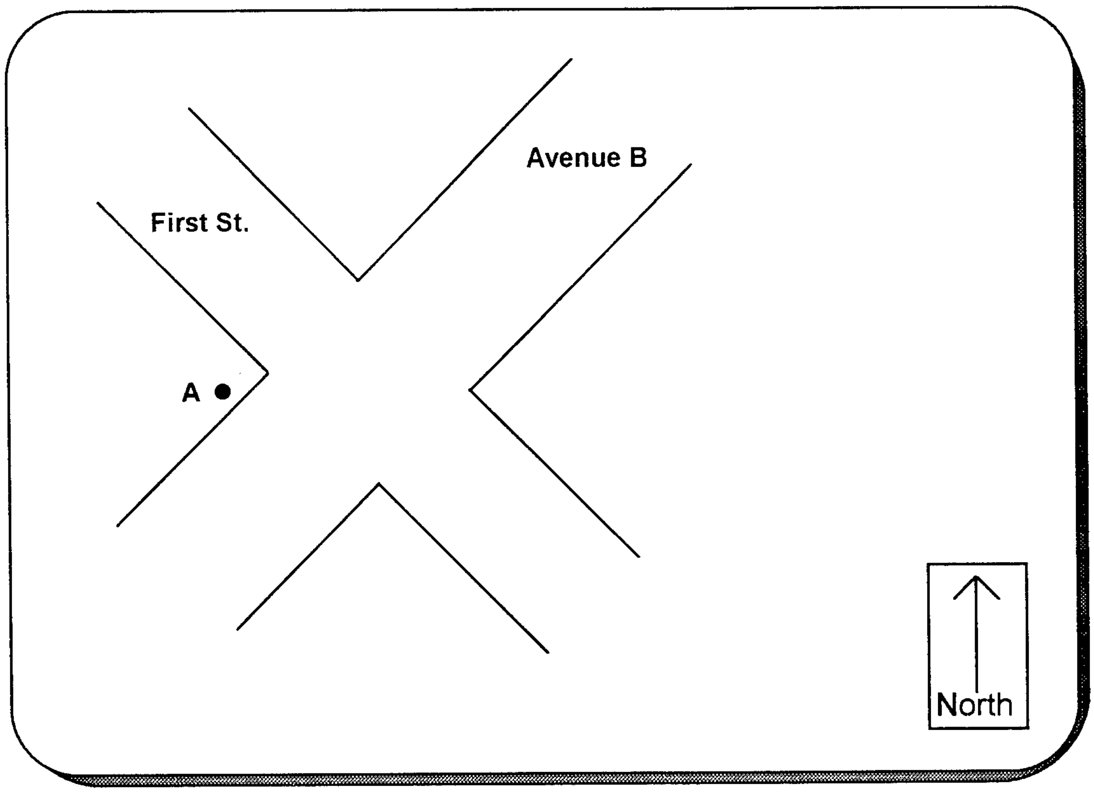
Client: Fort Irwin, CA

Time: Leak Survey

Date: Thursday, December 12, 1996

Tech: Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= Hydrant

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: This is a hydrant leak.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA

Time: Leak Survey

Date: Thursday, December 12, 1996

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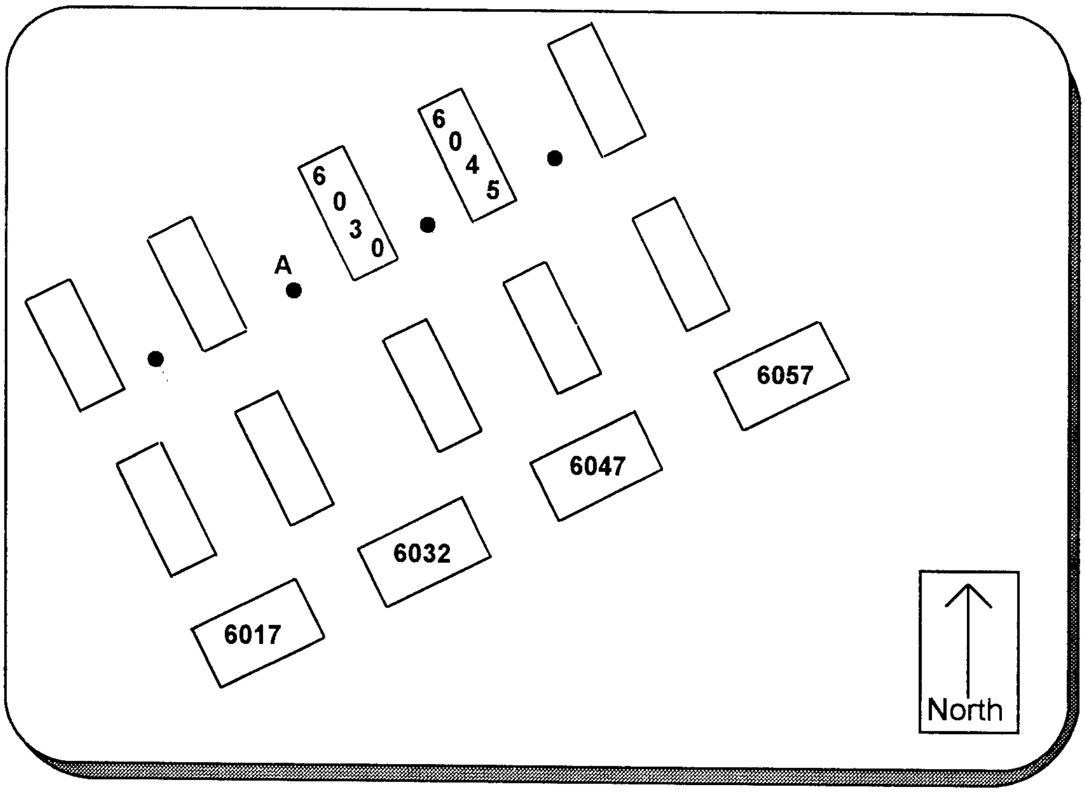

Distance:

Connection point: A= Hydrant

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: This is a hydrant leak.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA **Time:** Leak Survey

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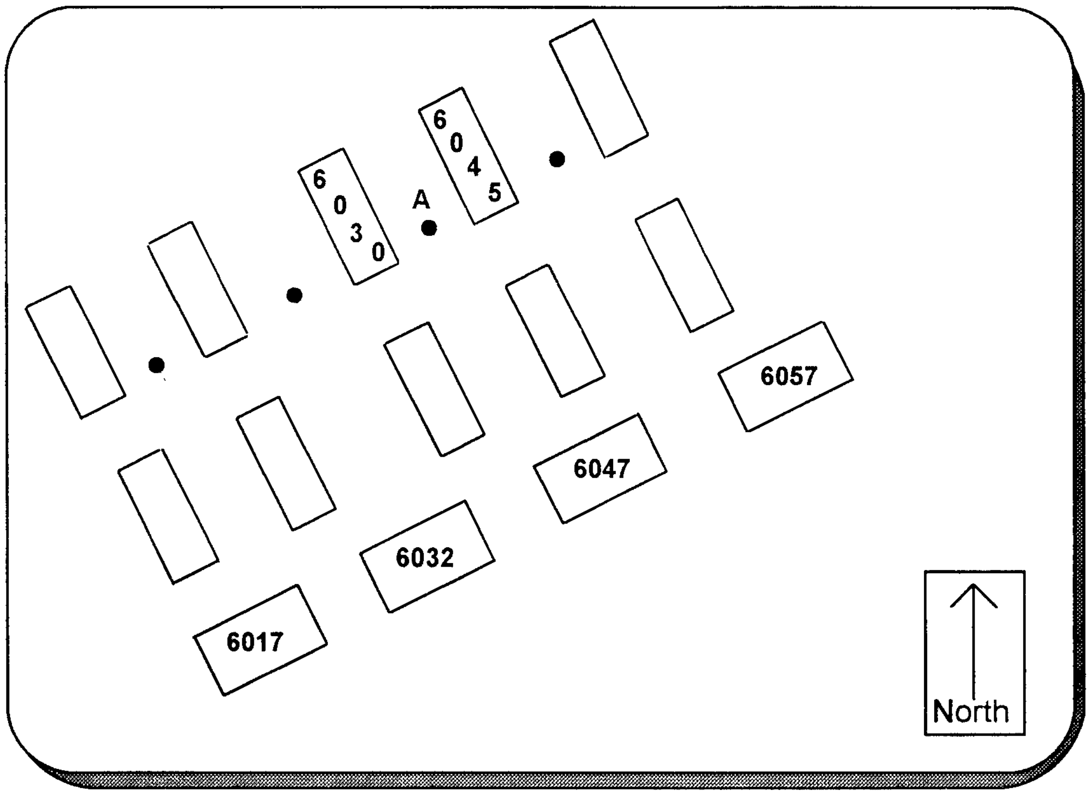
Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= Hydrant

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: This is a hydrant leak.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA **Time:** Leak Survey

Date: Thursday, December 12, 1996 **Tech:** Mike & John

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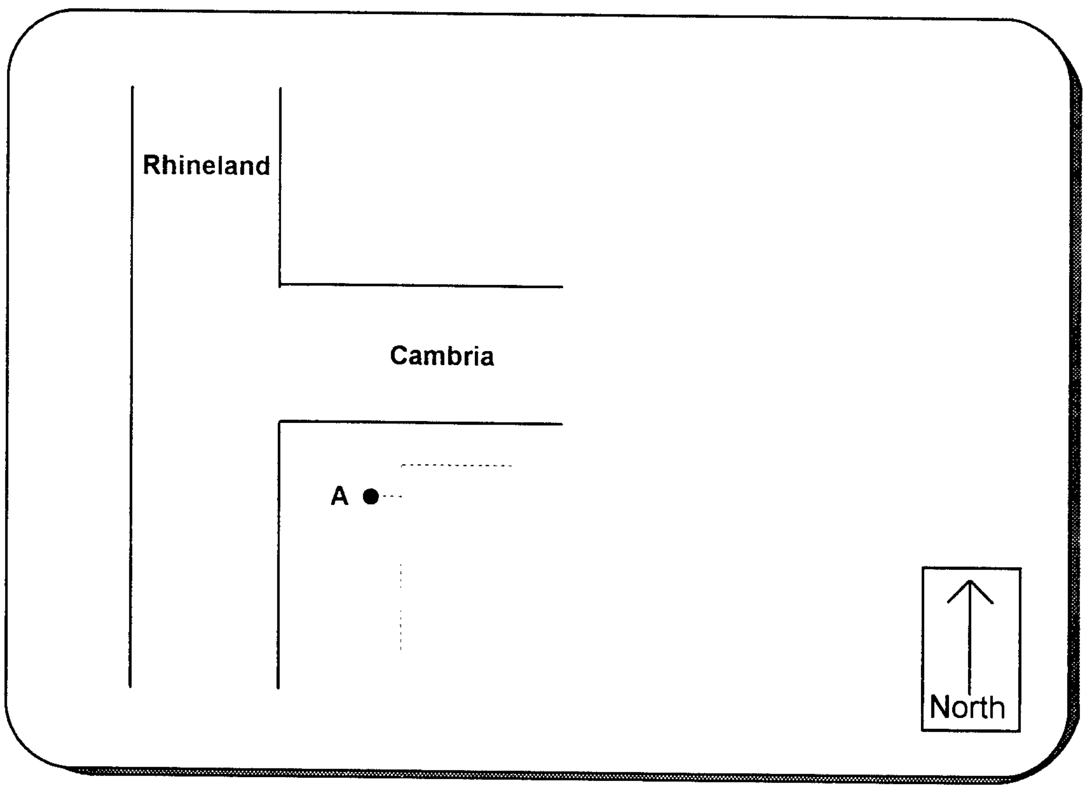


Distance:

Connection point: A= Hydrant

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: This is a hydrant leak.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

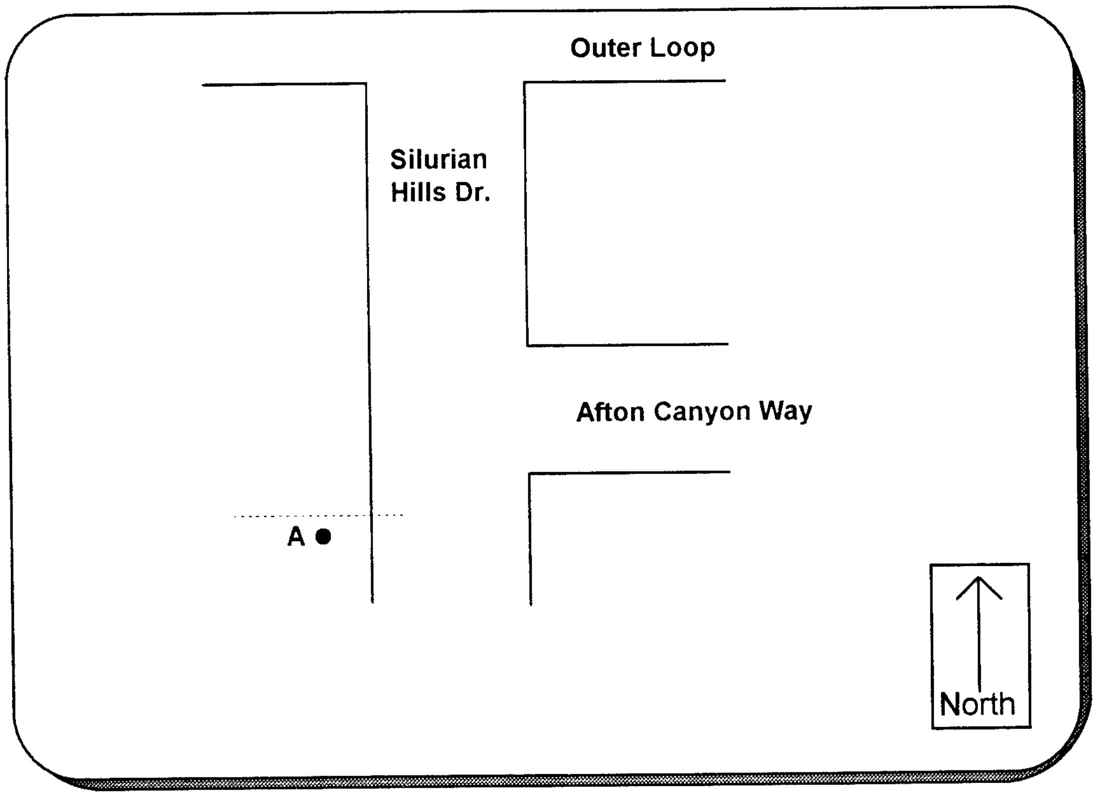
Client: Fort Irwin, CA

Time: Leak Survey

Date: Wednesday, December 11, 1996

Tech: Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= Hydrant

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: This is a hydrant leak.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

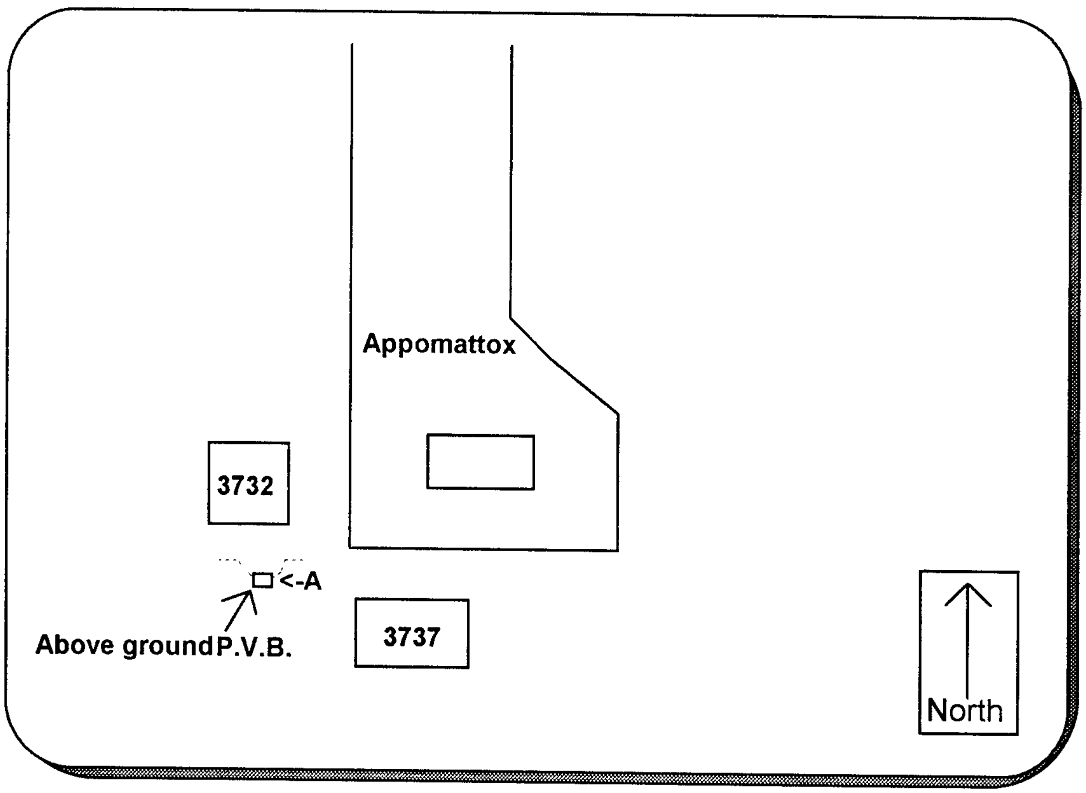
Client: Fort Irwin, CA

Time: Leak Survey

Date: Thursday, December 12, 1996

Tech: Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= P.V.B.

Connection point:

Connection point:

Connection point:

Leak Location: 0' from A

Comments: The P.V.B. needs to be repaired.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

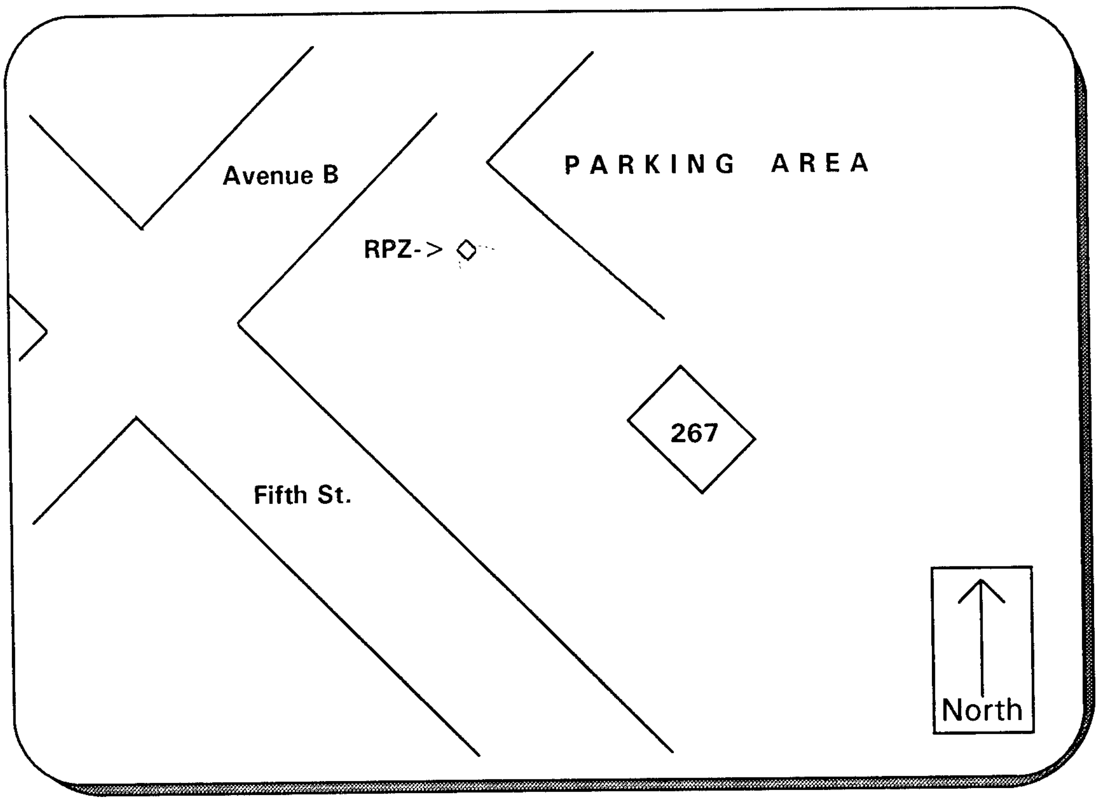
M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA   **Time:** Leak Survey

Date: Friday, December 13, 1996   **Tech:** Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= RPZ

Connection point:

Leak Location: 0' from A

Comments: This leak is beyond the RPZ and is contained within the irrigation system.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

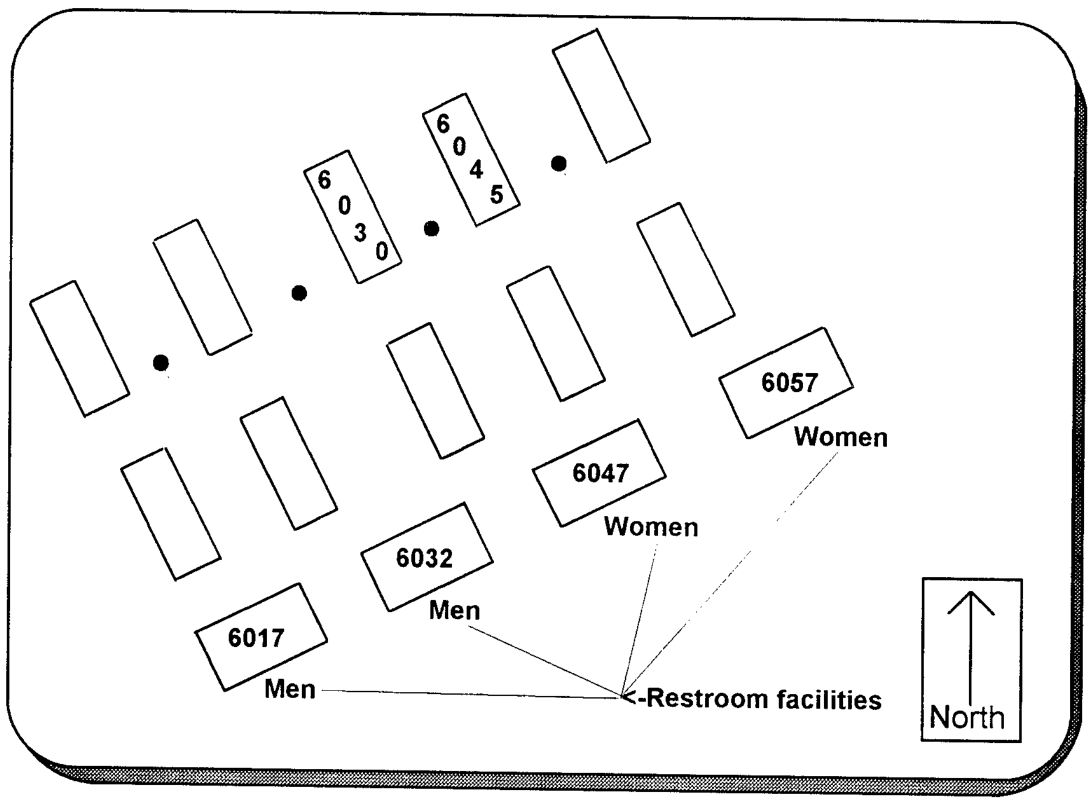
M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

Client: Fort Irwin, CA **Time:** Leak Survey

Date: Thursday, December 12, 1996 **Tech:** Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point:

Connection point:

Connection point:

Connection point:

Leak Location: Men and women's restroom facilities

Comments: These restroom facilities need to be inspected and leaking fixtures repaired.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

M.E. SIMPSON COMPANY, INC. - Professional Services

LEAK LOCATION REPORT

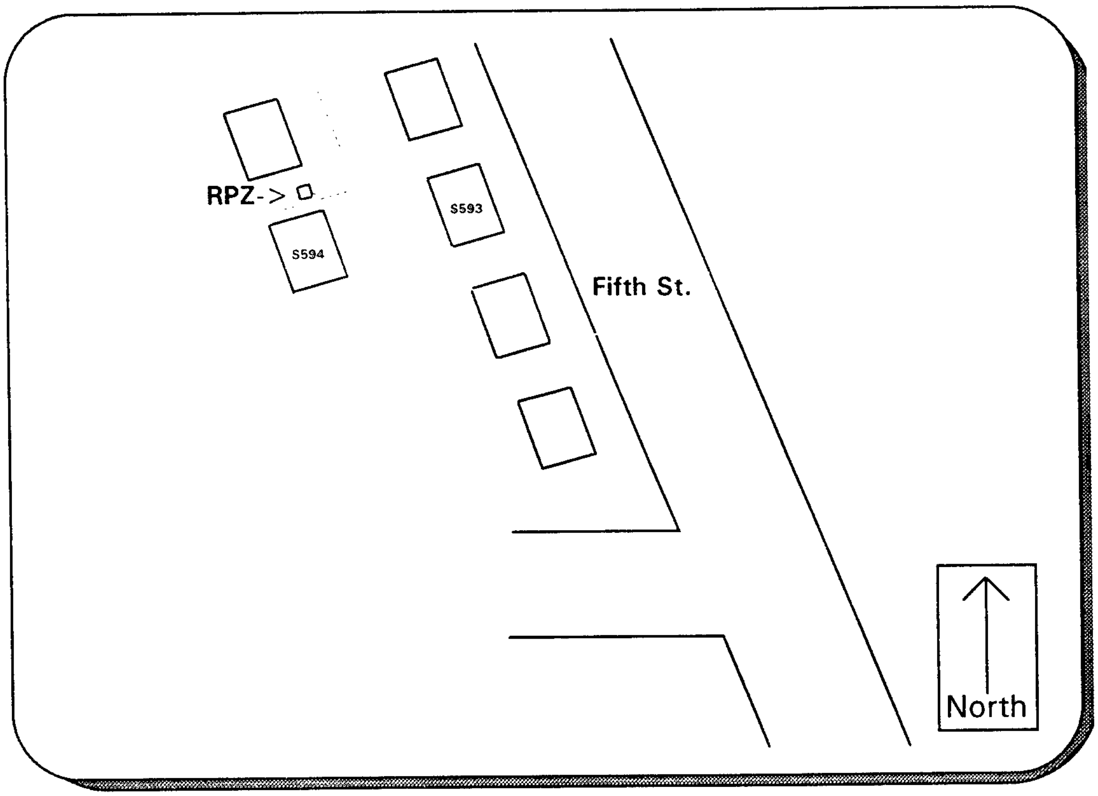
Client: Fort Irwin, CA

Time: Leak Survey

Date: Friday, December 13, 1996

Tech: Mike & John

Below is a diagram of the area surveyed for a suspect leak.



Distance:

Connection point: A= RPZ

Connection point:

Leak Location: 0' from A

Comments: This leak is beyond the RPZ and is contained within the irrigation system.

We thank you for the opportunity to work for your Utility and look forward to serving you again. If you have any questions please don't hesitate to call.

APPENDIX C

Field Survey Data

APPENDIX C
Table of Contents

Booster Pump 1 (Bicycle Lake)

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Yes
Built-in Run Time Meters?	Yes

Name Plate Data

Manufacturer:	Marathon Electronics
Model Number:	RM 445TSTDS7026FP W
Serial Number:	09-02285-11 (from Bakersfield Pump Tests)
460 V 60 Hz 3 Ph 231 Amps, Corr Amps: 209	
HP:	200
RPM:	1780
NOM PF:	86.0%
Max Cap KVAR:	45
NEMA Nom. Eff:	94.1%
SF:	1.15

Measured Data

12/12/96	12:00 PM	1634 GPM, (5 min avg)	Pump on, solo
12/14/96	3:35 PM	460 V, 460 V, 462 V	
		Hours = 24971.1	

Booster Pump 2 (Bicycle Lake)

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Yes
Built-in Run TIme Meters?	Yes

Name Plate Data

Manufacturer:	Marathon Electronics
Model Number:	RM 445TSTDS7026FP W
Serial Number:	09-02285-11/22-01 (from Bakersfield Pump tests)
460 V 60 Hz 3 Ph 231 Amps, Corr Amps:209	
HP:	200
RPM:	1780
NOM PF:	86.0%
Max Cap KVAR:	45
NEMA Nom. Eff:	94.1%
SF:	1.15

Measured Data

12/12/96	11:40 AM	1430 GPM, pump on, solo
12/12/96	11:50 AM	pump off
12/14/96	3:35 PM	462 V, 460 V, 460 V
		Hours = 26316.9

Booster Pump 3 (Bicycle Lake)

General Information

yes	Telemetered?	Yes
	Capacitor?	No
	Built-in Run Time Meters?	Yes
	Built-in Flow Meters?	Yes

Name Plate Data

Manufacturer:	Marathon Electronics
Model Number:	RM 445TSTDS7026FP W
Serial Number:	
460 V 60 Hz 3 Ph 231 Amps, Corr Amps:209	
HP:	200
RPM:	1780
NOM PF:	86.0%
Max Cap KVAR:	45
NEMA Nom. Eff:	94.1%
SF:	1.15

Measured Data

12/12/96	prior to 11:40	pump on, solo
12/12/96	11:40 AM	pump off
12/14/96	3:35 PM	462 V, 462 V, 462 V

Well B-1 (Bicycle Lake)

General Information

Telemetered?	Yes
Capacitor?	Yes (10 kVAR)
Built-in Flow Meters?	Yes
Built-in Run Time Meters?	Yes

Name Plate Data

Manufacturer:	US Motors
Model Number:	
Serial Number:	
460 V, 60 Hz, 3 Ph, 144 Amps	
HP:	125
RPM:	1780
PF:	87.0%
Max KVAR:	23.5
NEMA Eff:	93.0%
SF:	1.15

Discharge dia = 7 7/8" (from Bakersfield Pump Co. - pump eff. test)

Measured Data

12/12/96	2:35 PM	1787 RPM
-		284 V, 104 A, 0.78 PF, well 4 on
-		284 V, 104 A, 0.75 PF, well 4 on
-		285 V, 106 A, 0.78 PF, well 4 on
-		734 GPM (5 min avg)
12/14/96	2:37 PM	40 psi, pump on, meas at services, before cap
		Hours = 13016.1
		496 V, 500 V, 498 V
		100 A, 98.6 A, 96.1 A
		0.85 PF, 0.84 PF, 0.84 PF

Fort Irwin - Domestic Water System Survey Data

Well B-4 (Bicycle Lake)

General Information

Telemetered?	Yes
Capacitor?	Yes (30 kVAR)
Built-in Flow Meters?	Yes
Built-in Run Time Meters?	Yes

Name Plate Data

Manufacturer:	U.S. Electrical Motors
Model Number:	
Serial Number:	
460 V 60 Hz 3 Ph 146 Amps	
HP:	125
RPM:	1780
F.L. PF:	-
Max KVAR:	-
NEMA Nom. Eff:	94.5%
SF:	1.15

Capacitor: 'Westinghouse 30KVAR, 792080 1A36 style, 3Ph 60 Hz 480 V
Discharge dia = 8" (from Bakersfield Pump Co. - pump eff. test)

Measured Data

12/12/96	3:23 PM	472 GPM (6 min avg), well B-1 also on
	-	1791 RPM
	-	290 V, 85.8 A, 0.78 PF
	-	274 V, 89.3 A, 0.79 PF
	-	276 V, 90.0 A, 0.80 PF
	3:35 PM	Hours = 19675.3
12/14/96	3:10 PM	18 psi, pump on
		472 V, 472 V, 468 V
		amps and PF as prev. measured
		Hours = 19675.5

Fort Irwin - Domestic Water System Survey Data

Well B-5 (Bicycle Lake)

General Information

Telemetered?	Yes
Capacitor?	Yes (10 kVAR)
Built-in Flow Meters?	Yes
Built-in Run Time Meters?	Yes

Name Plate Data

Manufacturer:	U.S. Electrical Motors
Model Number:	
Serial Number:	
460 V 60 Hz 3 Ph 145 Amps	
HP:	125
RPM:	1780
F.L. PF:	87.1%
Max KVAR:	23.6
NEMA Nom. Eff:	94.5%
SF:	1.15

WB 5, 5997

No vault, all above ground.
Discharge dia = 8" (from Bakersfield Pump Co. - pump eff. test)

Measured Data

12/12/96	2:59 PM	396 GPM, (5 min avg), well 4 also on
	-	1788.5 RPM
	-	404 V, 116 A, 0.83 PF
	-	336 V, 120 A, 0.82 PF
	-	306 V, 120 A, 0.86 PF
	3:42 PM	Hours = 17036.8
12/14/96	2:22 PM	40 psi, pump on
		468 V, 472 V, 484 V
		Hours = 17067.7

Fort Irwin - Domestic Water System Survey Data

Well B-6 (Bicycle Lake)

General Information

Telemetered?	Yes
Capacitor?	Yes (10 kVAR)
Built-in Flow Meters?	Yes
Built-in Run Time Meters?	Yes

Name Plate Data

Manufacturer:	High Thrust U.S. Electric Motors
Model Number:	
Serial Number:	
460 V 60 Hz 3 Ph 144 Amps	
HP:	125
RPM:	1784
PF:	86.2%
KVAR:	24.5
NEMA Nom. Eff:	94.5%
SF:	1.15
6 " dia Pipe	

Measured Data

12/12/96	2:10 PM	276 V, 110 A, 0.78 PF, B-4 well on
	-	276 V, 112 A, 0.77 PF, B-4 well on
	-	276 V, 112 A, 0.78 PF, B-4 well on
	-	764 GPM (5 min avg)
	-	1792 RPM
12/14/96	3:25 PM	30 psi, pump off
	-	35 psi, pump on
	-	850 GPM off of attached flowmeter
		488 V, 488 V, 492 V
		PF same as before
		No run time meter

Langford Booster Pump 1

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Yes (broken)
Built-in Run Time Meters?	Yes
Built-in kW/kWh Meters?	Yes

Name Plate Data

Manufacturer:	
Model Number:	5K444AL218c
Serial Number:	TD251036
460 V 60 Hz 3 Ph 179 Amps	
HP:	150
RPM:	1780
PF:	
Max KVAR:	-
NEMA Nom. Eff:	-
SF:	1.15

Measured Data

12/11/96 1:05 PM Hours = 6409.5
12/14/96 11:50 AM Hours = 6409.5

Langford Booster Pump 2

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Yes (Malfunctioning)
Built-in Run Time Meters?	Yes
Built-in kW/kWh Meter?	Yes

Name Plate Data

Manufacturer:	U.S. Motors
Model Number:	
Serial Number:	
460 V 60 Hz 3 Ph 172 Amps	
HP:	150
RPM:	1785
FL PF:	87.0%
Max KVAR:	27.5
NEMA Nom. Eff:	96.2%
SF:	1.15

Measured Data

12/11/96	1:05 PM	Hours = 11275.9
	-	1790 RPM
12/14/96	11:50 AM	Hours = 11296.0
	-	464 V, 464 V, 466 V (solo)
	-	460 V, 462 V, 462 V (w/ Booster Pump 3 on also)

Langford Booster Pump 3

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Yes (Malfunctioning)
Built-in Run Time Meters?	Yes
Built-in kW/kWh Meter?	Yes

Name Plate Data

Manufacturer:	U.S. Motors
Model Number:	
Serial Number:	
460 V 60 Hz 3 Ph 172 Amps	
HP:	150
RPM:	1785
FL PF:	87.0%
Max KVAR:	27.5
NEMA Nom. Eff:	96.2%
SF:	1.15

Measured Data

12/11/96	1:05 PM	Hours = 5117.25
	-	1792 RPM
12/14/96	11:50 AM	468 V, 468 V, 466 V (solo)
	-	Hours = 5117.7
	-	(w/Booster Pump 2 on also, see Langford Booster Pump 2)

Fort Irwin - Domestic Water System Survey Data

Well L-1 (Langford Basin)

Submersible pump; no nameplate data available.
125# flanges, similar to 12" pipe at the booster station
Cannot find a pipe section to measure; set ID to 6"
Discharge dia = 6 1/8" (from Bakersfield Pump Co. - pump eff. test)

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Yes (Malfunctioning)
Built-in Run Time Meters?	Yes
Built-in kW/kWh Meter?	Yes

Name Plate Data

Manufacturer:	
Model Number:	
Serial Number:	
(? V ? Hz ? PH ? Amps)	
HP:	125
RPM:	
PF:	
KVAR:	
NEMA Nom. Eff:	
SF:	

Measured Data

12/11/96	3:30 PM	384 GPM, 378 GPM, 380 GPM, 378 GPM
		- 264 V, 98.8 A, 0.90 PF
		- 264 V, 94.7 A, 0.84 PF
		- 266 V, 100 A, 0.85 PF
		- Hours = 4608.0
12/14/96	11:35 AM	4612.9 Hours
		- 470 V, 468 V, 470 V

Well L-2 (Langford Basin)

Submersible pump - no nameplate data available.
6" dia piping entered, adjust when exact meas. found.
Discharge dia = 6 1/8" (from Bakersfield Pump Co. - pump eff. test)

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Yes (Malfunctioning)
Built-in Run TimeMeters?	Yes
Built-in kW/kWh Meters?	Yes

Name Plate Data

Manufacturer:
Model Number:
Serial Number:
(? V ? Hz ? PH ? Amps)
HP:
RPM:
PF:
KVAR:
NEMA Nom. Eff:
SF:

Measured Data

12/11/96	Hours = 11251.2 , L3 also running
-	474 GPM, 480, GPM, 478 GPM
-	264 V, 102 A, 0.87 PF
-	264 V, 99.7 A, 0.88 PF
-	266 V, 99.3 A, 0.90 PF
12/14/96 11:25 AM	Hours = 11251.6
	462 V, 464 V, 466 V

Well L-3 (Langford Basin)

Submersible pump; no nameplate data available.
Discharge dia = 6 1/8" (from Bakersfield Pump Co. - pump eff. test)
Previously Named LP-1

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Malfunctioning)
Built-in Run Time Meters?	Yes
Built-in kW/kWh Meters?	Yes

Name Plate Data

Manufacturer:	
Model Number:	
Serial Number:	
(? V ? Hz ? PH ? Amps)	
HP:	125
RPM:	
PF:	
KVAR:	
NEMA Nom. Eff:	
SF:	

Measured Data

12/11/96	3:40 PM	Hours = 117235.0
	-	570 GPM, 576 GPM, 576 GPM
	-	136 A, 0.79 PF
	-	132 A, 0.78 PF
	-	132 A. 0.80 PF
12/14/96	11:15 AM	458 V, 460 V, 462 V
		Hours = 17257.6

Fort Irwin - Domestic Water System Survey Data

Well I-3 (Installation)

General Information

Telemetered?	Yes (Hours and Flow only)
Capacitor?	No
Built-in Flow Meters?	Yes
Built-in Run Time Meters?	Yes

Name Plate Data

Manufacturer:	U.S. Electric Motors
Model Number:	
Serial Number:	
460 V 60 Hz 3 Ph 117 Amps	
HP:	100
RPM:	1785
FL PF:	-
Max KVAR:	-
NEMA Nom. Eff:	95.4%
SF:	1.15

Discharge dia = 8" (from Bakersfield Pump Co. - pump eff. test)

Measured Data

12/14/96	1:20 PM	55 psi, running	
-		727 GPM (5 min avg), 8" pipe	
-		water meter = 875432 gal	
-		hours = 8908.1	
-		1789.5 RPM	
		480V, 88.6A, 0.92 PF	On line side of contactor
		482V, 88.1A, 0.94 PF	
		480V, 85.0A, 0.95 PF	

Well I-5 (Installation, Bldg P-319)

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Yes
Built-in Run Time Meters?	Yes

Name Plate Data

Manufacturer:	U.S. Electric Motors
Model Number:	
Serial Number:	
450 V 60 Hz 3 Ph 114 Amp	
HP:	100
RPM:	1785
PF:	
KVAR:	
NEMA Nom. Eff:	95.2%
SF:	1.15

Chlorine pump directly attached, pumping every second.
Pumping action causes oscillatory readings on installed flowmeter.
Installed Flowmeter oscillates between 500-550 GPM.
Discharge dia = 6" (from Bakersfield Pump Co. - pump eff. test)

Measured Data

12/14/96	12:10 PM	Hours = 15238.8
	-	Flowmeter 11,718,700 Gallons
	-	656 GPM, (5 min avg), 6" pipe
		468 V, 85.9 A, 0.90 PF
		470 V, 90.2 A, 0.92 PF
		468 V, 84.7 A, 0.93 PF
		1790 RPM
		525 GPM on meter

Well I-7 (Installation)

General Information

Telemetered?	Yes
Capacitor?	No
Built-in Flow Meters?	Yes
Built-in Run TIme Meters?	Yes

Name Plate Data

Manufacturer:	U.S. Electrical Motor
Model Number:	
Serial Number:	
440 V 60 Hz 3 Ph 240 Amps	
HP:	200
RPM:	1775?
PF:	
KVAR:	
NEMA Nom. Eff:	
SF:	

Amp Meter installed.
Nameplate somewhat illegible.
Clorine tank attached.
Discharge dia = 8" (from Bakersfield Pump Co. - pump eff. test)

Measured Data

12/14/96 1:53 PM 1446 GPM, (7 min avg), 8" dia pipe
1270 GPM steady after 10+ min of running.
1777.0 RPM
Hours = 15109.7
1000 GPM @ meter
63571 gallons
460 V, 230 A, 0.86 PF
442 V, 200 A, 0.80 PF
440 V, 184 A, 0.95 PF

Fort Irwin - Domestic Water System Survey Data

Booster Pumps @ JPL Building G-92 (Goldstone) - Typical For 2

Goldstone receives water & power from Ft. Irwin and then gets billed for same.
Curt Mitchelle (619) 255-8222 (JPL - Liaison)

General Information

Telemetered?
Capacitor?
Built-in Run Time Meters? Yes (Malfunctioning)
Built-in Flow Meters?

Name Plate Data

Pump

Serial #: TA1236 RPM:3600 BHP: 75
U.S. GPM: 150 TDH: 110 ft
Size & Type:7AC Stages: 11
Johnston Pump Co., SP GR: 1.0

Motor

Manufacturer:	U.S. Electrical Motors
Model Number:	
Serial Number:	
230/460 V 60 Hz 3 Ph 172/86 Amps	
HP:	75
RPM:	3530
PF:	
KVAR:	
NEMA Nom. Eff:	89.5%
SF:	1.15

Measured Data

12/17/96

> 500 psi
~ 150 GPM 75 HP
~ 500-525 psig operation. updates every 30 min.

Fort Irwin - Ice Maker System Name Plate Data

Ammonia Tank:

Natural Board #: 935
300 psi@150 F (Max Allowable Working Press)
-5-degrees F @ 300 psi (Min Design Metal Temperature)
Year built: 1993
Manufacturer Serial No: 93-110
Manufacturer: Turbo Refrigerating Co.

MLL-A Turbo Ice Maker:

Model No: TIGAR 50FLSCE
Serial No: 930380
Test pressures Lo-side 150 psi Hi-side 350 psi
Refrig: R717 Charge: 575 lbs.
Oil: SUNISO 3GS Charge: 7 Gal
3 Phase FLA: 156 460 V 3 Ph 60 Cyc.
Controls FLA: 5 110 V Ph 1 60 Cyc.

	Qty	HP	FLA	LRA	V	CYC	PH
Comp. Fan	-	-	-	-	-	-	-
Compressor	1	100	121	-	460	60	3
Crusher	1	2	2.9	-	460	60	3
Water Pump	2	1	1.8	-	460	60	3
Cond. Fan	1	10	13.6	-	460	60	3
Evap. Cond.	1	1.5	2.4	-	460	60	3
Pump Transformer	1	1.5kVA	3.3	-	460	60	1
Oil Cooller	1	75	1.3	-	460	60	3
Roofscrew	1	5	7.6	-	460	60	3

MCS:

Model No: TIGAR 50FL SCE
Serial No: 930380
Oil: - Charge: -
3 Phase FLA: - Volts: - Ph: - Cyc: -
Controls FLA: 10 Volts: 110 Ph: 1 Cyc: 60
Turbo Refrigerating Company

Compressor Motor:

Model No: ZF 444TSTFS 8076AN W Frame: -
Type: TFS Des: B Ph: 3 Ins Class: F1 Duty: Cont Max Amb Degrees C: 40
ENCL: TEFC

Low Voltage Line	High Voltage Line
HP: 100 Volts: 230/460	HP: 75 Volts: 190/380
Hz: 60 SF:1.15 RPM:1185	Hz: 50 SF:1.15 RPM:985
FL Amps: 242/121 Code: G	FL Amb: 222/121
Corr Amps: 206/103	

Max Capacitor kVAR: 36.5
NEMA Nom Eff: 93.0 Nom P. Ser. 19-072470-6/7

Knockoff:

Nat'l BD 5998 Certified by HA Philips & Co.
MAWP: 300 psi @650'F
20 degrees F MDMT @300 psi
p-4220 Ser. No: 5998
031531 Year: 1993
Phillips Pressure Vessels

Compressors:

VML 450XL

Compressor CW Pump (From & To Evap Cond Fan):

Pump: Aurora No 05-9229/11 GPM
Type 321-BF Head 50Ft
Size 0.75x1x7B 1750RPM
Motor Aurora Pump
Part 952-2291-940
Model 2Vc56T17F55038-R26-P
FR. 56CZ-70 3Ph Type TS
40 degrees C Insulation, B-3 .
Design B
Duty: Continuous
60 Hz 1HP 1725 RPM
208-230/460V, 3.5-3.6/1.8 FLA
SF: 1.15

Fan Motor:

Manuf: U.S. Electric Motors
10 HP
Design B
208-230/460V, 30.0-27.2/13.6 FLA
Duty: Cont
SF: 1.15

Reverse Osmosis Plant Annual Production and Flow Diagram

Revised April 1997

The data and diagram below reflect a year's worth of manual data collection from flow meters installed in the Reverse Osmosis Plant. Raw water feed is shown to the left in the diagram; processing proceeds to the right. Well 2A is the primary feed to the RO Plant; some feed is from a connection to the domestic water system (5/8" meter). Backwash of inlet filters consumes some water before processing. The unit feed value is water actually flowing into the reverse osmosis membrane assemblies. When unit feed metered total flow is checked against the totals of brine and product added from separate meters and from the RO unit product meter, the largest difference between meter readings is about 4.7%, with the least at about 1.3%. These differences are not unexpected, as the differences are within nominal metering accuracy.

Total Potable Well Water Production

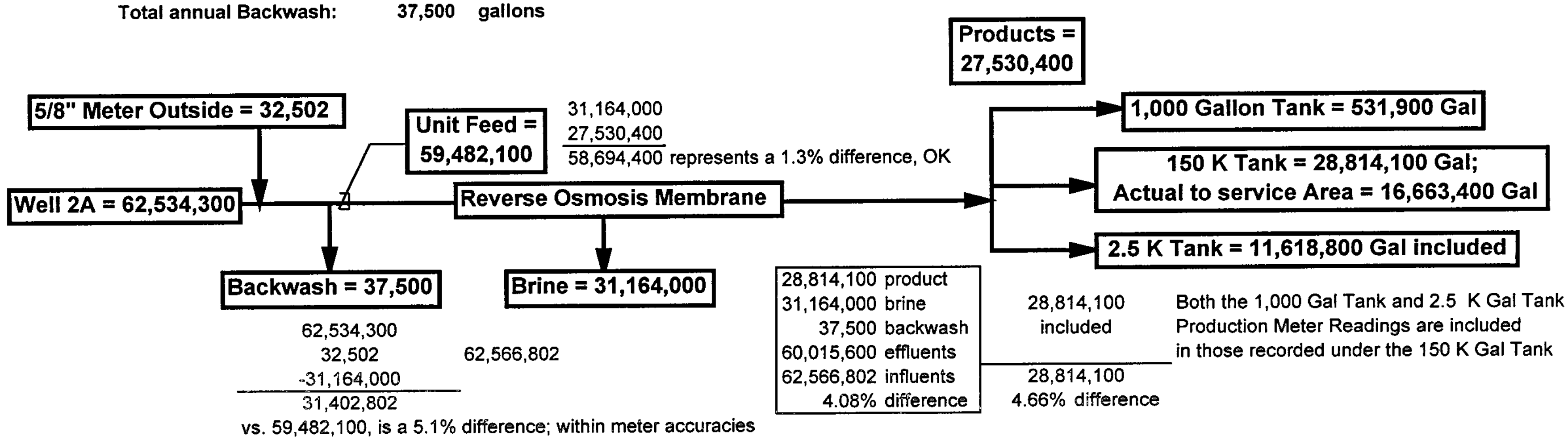
D/Mo/Yr Meter Mult.	Raw Water Gallons Mult X100	1,000 Gal Tank Gal Mult X100	Backwash Gallons Mult X100	Unit Feed Gal Mult X100	Brine Gallons Mult X100	Product Flow Gal Mult X10	150 K Gal Tank Mult X100	Well 2A Flow Gal Mult X100	Well 2A Timer Hr	2.5 KG Tank Mtr Mult X100	5/8" Meter Outside	Gravity Feed
01-Dec-95			0									
01-Jan-96	38,388	1,273	39	30,400	17,657	169,282	17,436	38,110	418.1	7,848.0	597	1,740
01-Feb-96	44,811	1,361	57	40,507	20,502	197,932	19,972	44,278	477.6	3,055.0	600	1,811
01-Mar-96	54,032	943	20	51,093	24,966	235,172	24,571	52,705	578.0	O/S	900	1,800
01-Apr-96	67,156	122	55	59,493	31,375	279,440	29,409	62,764	674.4	13,315.0	1,180	1,633
01-May-96	47,045	125	12	41,842	22,079	208,963	21,508	42,788	498.2	12,243.0	1,161	2,205
01-Jun-96	46,989	479	20	45,625	22,200	208,555	21,572	46,204	497.4	9,557.0	1,444	2,580
01-Jul-96	50,561	134	18	46,996	24,019	222,549	22,994	47,564	515.0	11,787.0	2,207	3,162
01-Aug-96	58,403	263	20	54,953	28,207	254,352	26,790	56,177	608.6	11,634.0	4,883	2,430
01-Sep-96	65,688	162	19	61,508	32,081	289,711	29,655	65,209	708.5	11,864.0	4,883	3,137
01-Oct-96	57,802	95	19	53,367	28,283	244,862	24,873	56,476	1,060.7	11,559.0	4,883	2,111
01-Nov-96	66,090	1	38	62,781	34,355	277,707	28,587	74,958	274.6	13,099.0	4,883	2,180
01-Dec-96	49,226	361	58	46,256	25,916	161,719	20,774	38,110	558.3	10,227.0	4,883	1,597
Totals	**646,191**	**5,319**	**375**	**594,821**	**311,640**	**2,750,244**	**288,141**	**625,343**	**6,869**	**116,188**	**32,502**	**26,386**

Metering: **Dedicated meters are installed unless otherwise noted**

Flow to the 20,000 gallon tank is through a 2,500 gallon hydrostatic tank; flow measurements to it are included in flows measured to the 150 K Gallon Tank

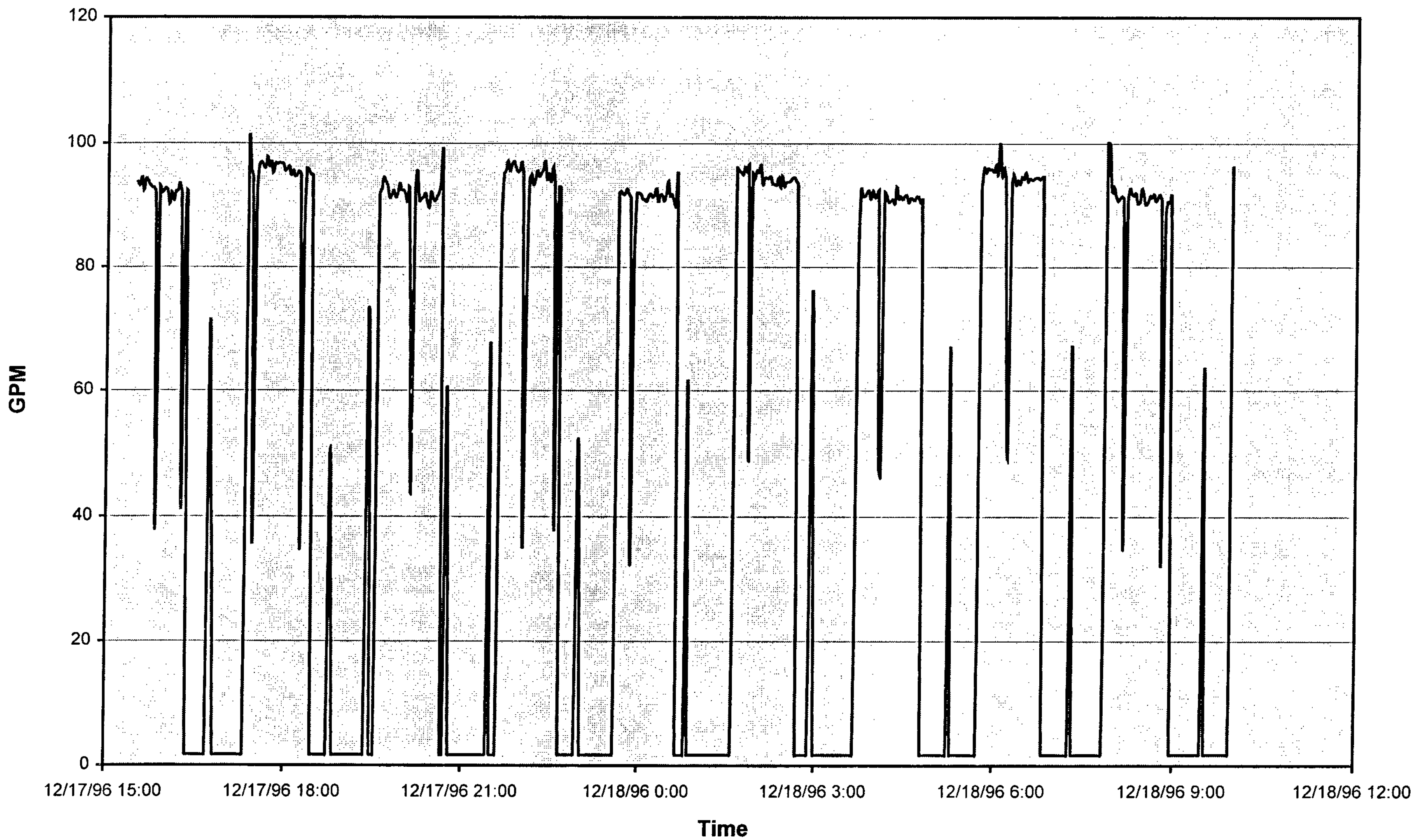
Backwash occurs periodically; flows are adjusted for the last several months due to a meter reset or replacement.

Total annual Backwash: 37,500 gallons

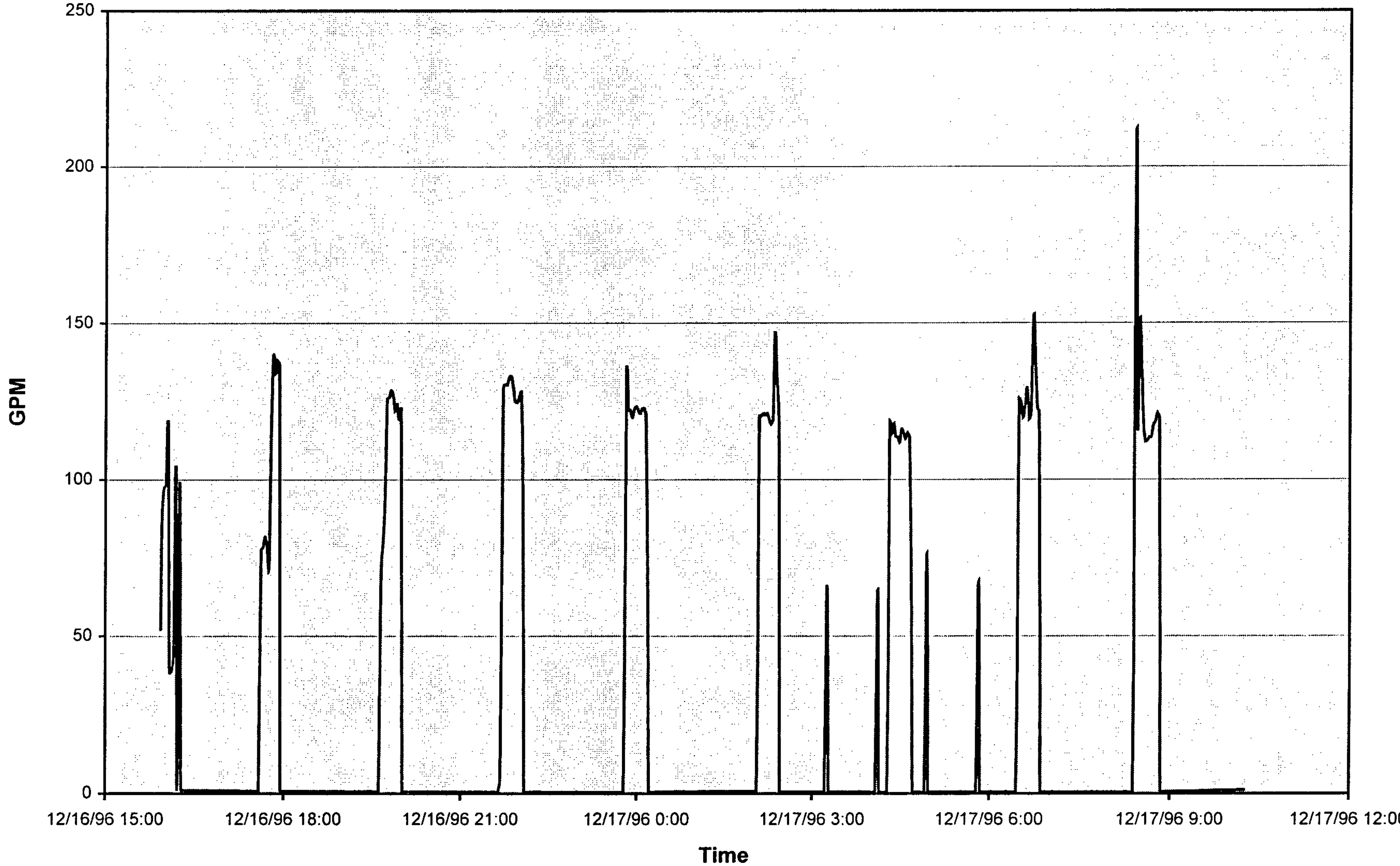


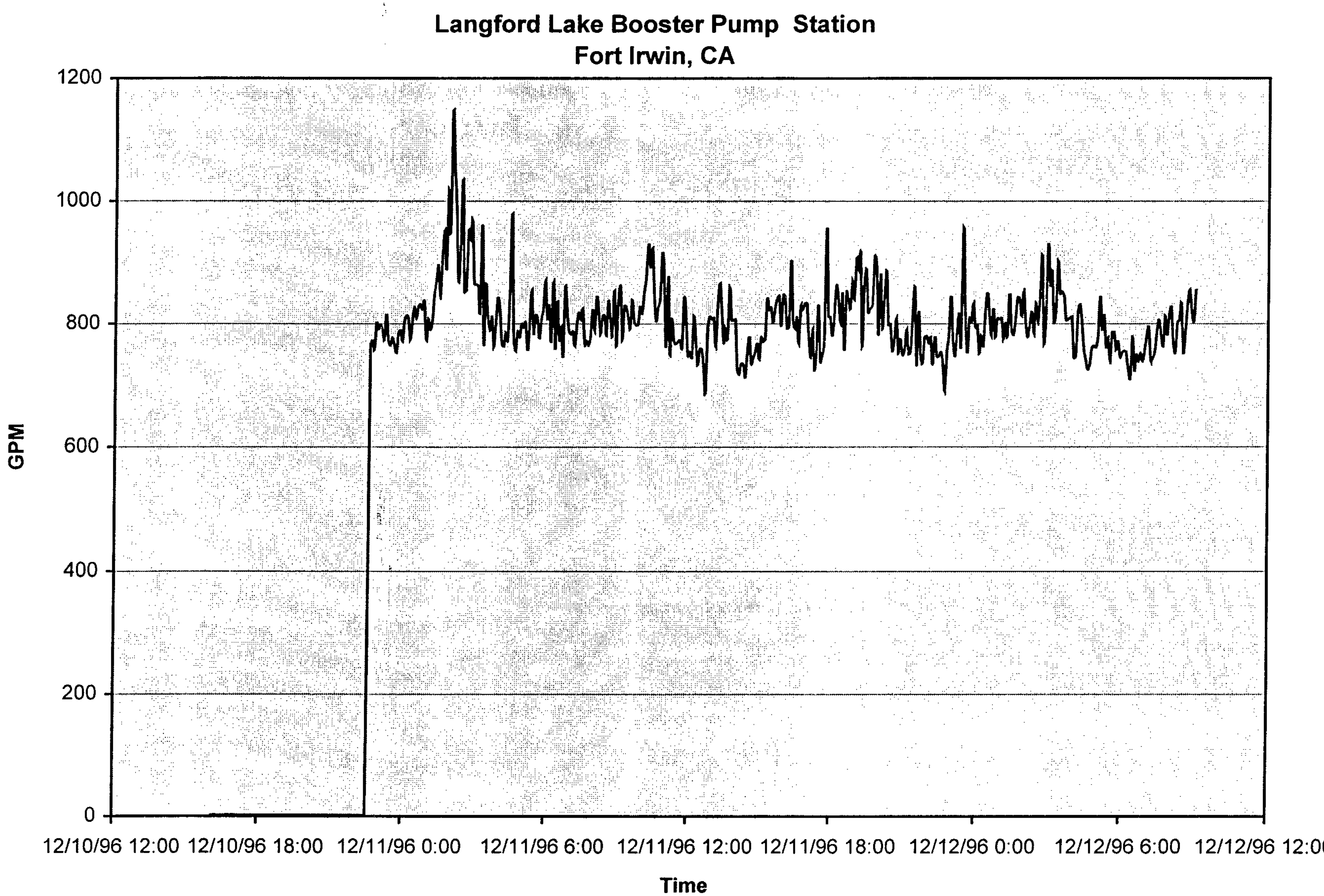
F:\PROJ\1640321\ENGR\Histprod RO Plant

R O Plant Demineralized Water Output (Blue Line)
Fort Irwin, CA



R O Water 150,000 Gallon Tank
Fort Irwin, CA




Langford Lake Booster Pump Station
Fort Irwin, CA
1200
1000
800
600
400
200
0
GPM
12/10/96 12:00
12/10/96 18:00
12/11/96 0:00
12/11/96 6:00
12/11/96 12:00
12/11/96 18:00
12/12/96 0:00
12/12/96 6:00
12/12/96 12:00
Time

APPENDIX D

Water Production Cost Calculations and Backup Data

APPENDIX D
Table of Contents

Σ

Current Fort Irwin Electricity Rate Structure

Fort Irwin is supplied electricity by Southern California Edison Co. (SCE) under SCE's time of use rate schedule TOU-8 with an Incremental Sales Rate (ISR) rider (schedule TOU-8-CR-1.) The ISR agreement provides for a base level of kWh consumption and kW demand billed at a fixed monthly amount, with consumption and demand above the base levels billed at the incremental rates, which are lower than the base rates. Fort Irwin is billed for the base level of energy regardless of whether it is actually used. In FY1996, Fort Irwin exceeded both the base consumption and demand levels during all rate periods throughout the year.

The SCE TOU-8 rate schedule provides for six distinct periods of usage, each with its own applicable rates. During the summer months, June through September, there are on-peak, mid-peak and off-peak periods. During the remaining eight (so-called winter) months, there are mid-peak, off-peak and super off-peak periods. A demand charge is assessed during the summer months for the maximum demand that occurs during the on-peak and mid-peak periods. A non-time-related demand charge is assessed for the maximum demand obtained each month, regardless of the time period in which it occurs. The following tables list the current applicable consumption and demand rates for each time period.

Electricity Consumption Rates at Fort Irwin Main Post ($ per kWh)
(From Revised Cal. PUC Sheet No. 21294-E)

Rate Component	Summer On Peak	Summer Mid-Peak	Summer Off-Peak	Winter Mid-Peak	Winter Off-Peak	Winter Super Off-Peak
Base	0.00549	0.00549	0.00549	0.00549	0.00549	0.00549
Base Adjustment	0.08873	0.05298	0.03209	0.06522	0.03325	0.03325
Base Total	0.09422	0.05847	0.03758	0.07071	0.03874	0.03874
Incremental *	0.03031	0.0195	0.01617	0.02290	0.01867	0.01867
Incremental Adjmt.	N/A	N/A	N/A	N/A	N/A	N/A
Incremental Total *	0.03031	0.0195	0.01617	0.02290	0.01867	0.01867

* Incremental rates are revised monthly by SCE.

Demand Rates at Fort Irwin Main Post ($ per kW)

Rate Component	Summer On Peak	Summer Mid-Peak	Summer Off-Peak	Winter Mid-Peak	Winter Off-Peak	Winter Super Off-Peak
Base	17.95	2.70	0.00	0.00	0.00	0.00
Base Adjustment	N/A	N/A	N/A	N/A	N/A	N/A
Base Total	17.95	2.70	0.00	0.00	0.00	0.00
Incremental	2.00	0.17	0.00	0.00	0.00	0.00

Note: A non-time-related charge of $6.60 per kW is assessed for maximum demands during each month, regardless of the time of occurrence.

Time Periods In SCE Rate Schedule TOU-8

Rate Period	Description
On-Peak	Noon to 1800, summer weekdays except holidays
Mid-Peak	0800 to noon and 1800 to 2300, summer weekdays except holidays
	0800 to 2100 winter weekdays except holidays
Off-Peak	All other hours
Summer Season:	12:00 a.m. on first Sunday in June to 12:00 a.m. on first Sunday in October (122 days)
Winter Season:	12:00 a.m. on first Sunday in October to 12:00 a.m. on first Sunday in June (243 days)

Annual Hours Per Rate Period Under SCE Schedule TOU-8

Rate Component	Summer On Peak	Summer Mid-Peak	Summer Off-Peak	Winter Mid-Peak	Winter Off-Peak
Annual Hours	528	792	1608	2184	3648
Percentage	6.0	9.0	18.4	24.9	41.6

Total Historical Energy Consumption Per Rate Period - FY96

Rate Component	Summer On Peak	Summer Mid-Peak	Summer Off-Peak	Winter Mid-Peak	Winter Off-Peak
Annual kWh	7,782,887	10,751,562	18,948,553	20,440,837	26,053,292
Percentage	9.3	12.8	22.6	24.3	31.0

Historical Electricity Consumption/Demand and Base Quantities

FY1996 monthly electric power usage, demand and base quantities is shown in Figures D-1 through D-6 as follows:

Figure D-1: Overall Electric Power Usage
Figure D-2: Winter Period Electric Power Usage and Base Quantities
Figure D-3: Summer Period Electric Power Usage and Base Quantities
Figure D-4: Winter Period Electric Power Demand and Base Quantities
Figure D-5: Summer Period Electric Power Demand and Base Quantities
Figure D-6: Total Electric Power Usage For Summer and Winter Periods

Tables D-1 and D-2 summarize the percentage savings required to achieve base levels for each rate period in FY1996 for kWh consumption and kW demand, respectively. As shown, the base levels of both consumption and demand were exceeding during all rate periods in FY1996.

Future Projected Fort Irwin Electricity Rates

The incremental rate structure with Southern California Edison Co. as outlined above will remain

in force through 31 December 2001. At this point, dramatic changes in the method that Fort Irwin uses to procure electricity will begin with the advent of competition and unbundling of electricity generation, transmission and distribution in California. Thus, almost all of the energy savings generated by the projects recommended in this study will accrue after utility deregulation, which the California Public Utilities Commission plans to implement no later than January 1, 1998. The Governor of California's stated goal for electricity rate reductions after utility deregulation is at least 20 percent in future years.

Several studies projecting future rates for unbundled energy utility services to Fort Irwin after utiity deregulation have projected a considerable range of rates.

Therefore, due to the uncertainty associated with Fort Irwin's electricity rates in the future, the marginal savings rates assumed in this study will be the current SCE base rates. For savings that accrue consistently and year-round, an average annual kWh rate based on historical usage during each discrete rate period will be applied.

A recapitulation of electricity rates used in the life cycle cost analyses follows:

Rate Component	Summer On Peak	Summer Mid-Peak	Summer Off-Peak	Winter Mid-Peak	Winter Off-Peak	Winter Super Off-Peak
Base Total ($)	0.09422	0.05847	0.03758	0.07071	0.03874	0.03874

Annual Average Rate (Consumption Weighted) = $ 0.05393 per kWh
$ 15.80 per million BTU

Determination of Unit Cost of Domestic Water

Estimated Annual Domestic Water Pumping Electrical Demand and Consumption

Electrical energy consumption and demand for the well pumps and booster pumps in the domestic water supply system for each of the discrete rate periods is developed in the following table:

Pump Designaton	Electric Demand Input kW	Annual Operating Hours	Total Annual Electric Use kWh	Summer On-Peak kWh Use*	Summer Mid-Peak kWh Use*	Summer Off-Peak kWh Use*	Winter Mid-Peak kWh Use*	Winter Off-Peak kWh Use*
B-1	69.1	3,349.8	231,471	21,527	29,628	52,312	56,247	71,756
B-4	57.1	2,976.2	169,941	15,805	21,752	38,407	41,296	52,682
B-5	82.9	5,927.3	491,373	45,698	62,896	111,050	119,404	152,326
B-6	72.3	4.2	304	28	39	69	74	94
L-1	79.8	3,115.5	248,617	23,121	31,823	56,187	60,414	77,071
L-2	70.5	1,997.0	140,789	13,093	18,021	31,818	34,212	43,644
L-3	83.7	965.7	80,829	7,517	10,346	18,267	19,641	25,057
I-3	68.1	3,114	212,077	19,723	27,146	47,929	51,535	65,744
I-5	65.2	3,769.8	245,791	22,859	31,461	55,549	59,727	76,195
I-7	138.1	1,963.6	271,173	25,219	34,710	61,285	65,895	84,064
BL Booster 1	157.6	3,060.0	482,256	44,850	61,729	108,990	117,188	149,499
BL Booster 2	153.1	1,547.2	236,876	22,029	30,320	53,534	57,561	73,432
BL Booster 3	153.1	1,292.4	197,866	18,402	25,327	44,718	48,082	61,339
LB Booster 1	111.0	2,606.8	289,355	26,910	37,037	65,394	70,313	89,700
LB Booster 2	98.6	897.1	88,454	8,226	11,322	19,991	21,494	27,421
LB Booster 3	106.6	1,022.5	108,999	10,137	13,952	24,634	26,487	33,790
Totals	1,566.8	37,609.3	3,496,171	325,144	447,510	790,135	849,569	1,083,813
Cost	$253,508	-	$188,554	$30,635	$26,166	$29,693	$60,073	$41,987

* Estimated quantities based on the ratio of SCE billed kilowatthours for the rate period to total annual billed kilowatthours.

Domestic Water System Operations & Maintenance Costs

Labor Category	Quan.	Hourly Rate ($)	Annual Hours	Annual Cost ($)
Supervisor	1	35.00	2,080	72,800
Operator	7	26.00	2,080	378,560
Workers	1.5	25.00	2,080	78,000
Subtotal - Labor				$ 529,360
Maintenance Materials, including Safety Items				$ 250,000
Materials; Major Repairs, amortized over 10 years				$ 150,000
Total Cost				$ 929,360

Average Cost of Domestic Water Per Hundred Cubic Feet

On annualized basis, the average cost of water delivered to users at Fort Irwin may be calculated as follows:

$$\text{Cost per 100 cubic feet} = \frac{\text{kWh Cost + kW Cost + O\&M Costs}}{\text{Gallons Water Production/ 7.481 gal per cu.ft./ 100}} = \frac{\$1{,}371{,}422}{141{,}325{,}224 \text{ Cu Ft } /100}$$

Cost per 100 cubic feet = $0.9704 $1.2972 /1000 gallons

Component Costs:	Electric Demand:	$0.2398 /1000 gallons
	lectric Use:	$0.1783 /1000 gallons
	O&M:	$0.8790 /1000 gallons

Determination of Unit Cost of Potable (Reverse Osmosis) Water

Estimated Annual Reverse Osmosis System Electrical Demand and Consumption

Load Description/ Designaton	Input kW	Annual Operating Hours	Total Annual kWh Use	Summer On-Peak kWh Use	Summer Mid-Peak kWh Use	Summer Off-Peak kWh Use	Winter Mid-Peak kWh Use	Winter Off-Peak kWh Use
Hours per Billing Period	-	7,005	-	485	744	1,331	1,810	2,636
Well 2A	57.2	7,446	425,911	29,489	45,224	80,906	110,042	160,251
High Pressure Pump*	55.9	7,005	391,576	27,112	41,578	74,383	101,171	147,332
Demin. Supply Pump*	6.1	7,005	42,730	2,959	4,537	8,117	11,040	16,077
1000 Gallon Tank:	-	-	-	-	-	-	-	-
Booster Pump* **	59.6	5,254	313,120	21,680	33,247	59,480	80,900	117,813
20,000 Gallon Tank:								
Booster Pump* **	11.9	5,254	62,519	4,329	6,638	11,876	16,153	23,523
Chem. Inject./Transfer Pump	1.9	7,005	13,309	922	1,413	2,528	3,439	5,008
Filter Backwash Pump	13.0	9	117	8	12	22	30	44
Lift Pump	1.4	7,005	9,807	679	1,041	1,863	2,534	3,690
Cleaning Pump	9.5	2	19	1	2	4	5	7
Filter Booster Pump*	5.1	7,005	35,725	2,474	3,793	6,786	9,230	13,442
Totals	221.6	-	1,294,834	89,650	137,487	245,965	334,544	487,188
Cost	$35,855	-	$68,258	$8,447	$8,039	$9,243	$23,656	$18,874

* Duplex pump arrangement; only one pump operates at a time. Well recorded hours are based on running hour meter readings; plant operating hours are based on inspection of RO Plan Operator's Log.

** These pumps are on level control, assume they operate 75% of plant operating hours.

Reverse Osmosis Plant Operations & Maintenance Costs

Labor Category	Hourly Rate ($)	Annual Hours	Annual Cost ($)
Supervisor @ 4 hours/week	35.00	208	$ 7,280
Operator @ 4 hours/day	26.00	1,460	$ 37,960
Subtotal - Labor			$ 45,240
Maintenance Materials			$ 50,000
Total R O Plant Costs			$ 95,240

Average Cost of Reverse Osmosis Water Per Hundred Cubic Feet

On a annualized basis, the average cost of reverse osmosis water delivered to users at Fort Irwin may be calculated as follows:

$$\text{Cost per 100 Cubic Feet} = \frac{\text{R.O. Plant kWh \& kW Costs + O\&M Costs}}{\text{Gallons R.O. Water Produced/ 7.481 Gal. Per Cu. Ft./100}}$$

$$\text{Cost per 100 Cubic Feet} = \frac{\$199{,}353}{3{,}851{,}637 \text{ Cubic Feet } /100}$$

Cost per 100 cubic feet = $5.1758 $6.9186 /1000 gallons

Component Costs:	Electric Demand:	$1.2444	/1000 gallons
	lectric Use:	$2.3689	/1000 gallons
	O&M:	$3.3053	/1000 gallons

Determination of Unit Marginal Cost of Water for Economic Analyses

For calculating life cycle cost savings due to water conservation projects, the marginal cost of water will be used. Unlike the average cost of water developed above, the marginal cost does not include expenses for such items as maintenance materials, safety equipment and in-house labor that are not impacted by reduced water production. An allowance for the avoided cost of outside labor equal to 25% of the average labor cost is included as a marginal O&M cost savings.

Marginal Unit Cost of Domestic Water

$$\text{Cost per 100 cubic feet} = \frac{\text{kWh Cost + kW Cost + Marginal O\&M Costs}}{\text{Gallons Water Production/ 7.481 gal per cu.ft./ 100}} \qquad \frac{\$574{,}402}{\text{141,325,224 Cu Ft /100}}$$

Cost per 100 cubic feet = $0.4064 $0.5433 /1000 gallons

Component Costs:	Electric Demand:	$0.2398	/1000 gallons
	lectric Use:	$0.1783	/1000 gallons
	O&M:	$0.1252	/1000 gallons

Marginal Unit Cost of Reverse Osmosis Water

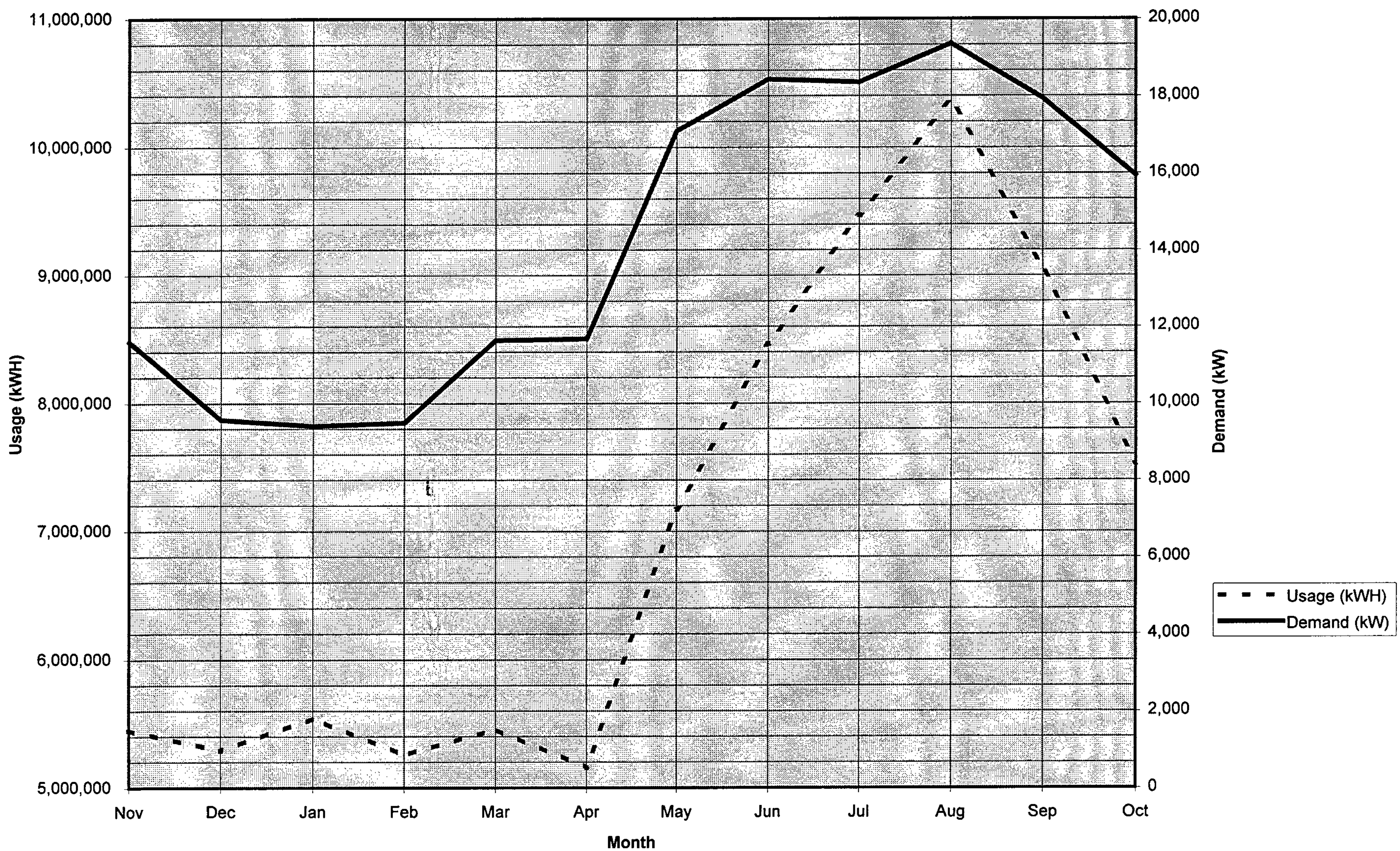
$$\text{Cost per 100 Cubic Feet} = \frac{\text{R.O. Plant kWh \& kW Costs + Marginal O\&M Costs}}{\text{Gallons R.O. Water Produced/ 7.481 Gal. Per Cu. Ft./100}}$$

$$\text{Cost per 100 Cubic Feet} = \frac{\$115{,}423}{\text{3,851,637 Cubic Feet /100}}$$

Cost per 100 cubic feet = $2.9967 $4.0058 /1000 gallons

Component Costs:	Electric Demand:	$1.2444	/1000 gallons
	lectric Use:	$2.3689	/1000 gallons
	O&M:	$0.3925	/1000 gallons

Figure D-1
FY1996 Electric Overall Power Usage, Fort Irwin, California



F:\PROJ\1640321\ENGR\RATES.XLS Billings Chart 2

Figure D-2
FY1996 Winter Period Electric Power Usage and Base Quantities
Fort Irwin, California

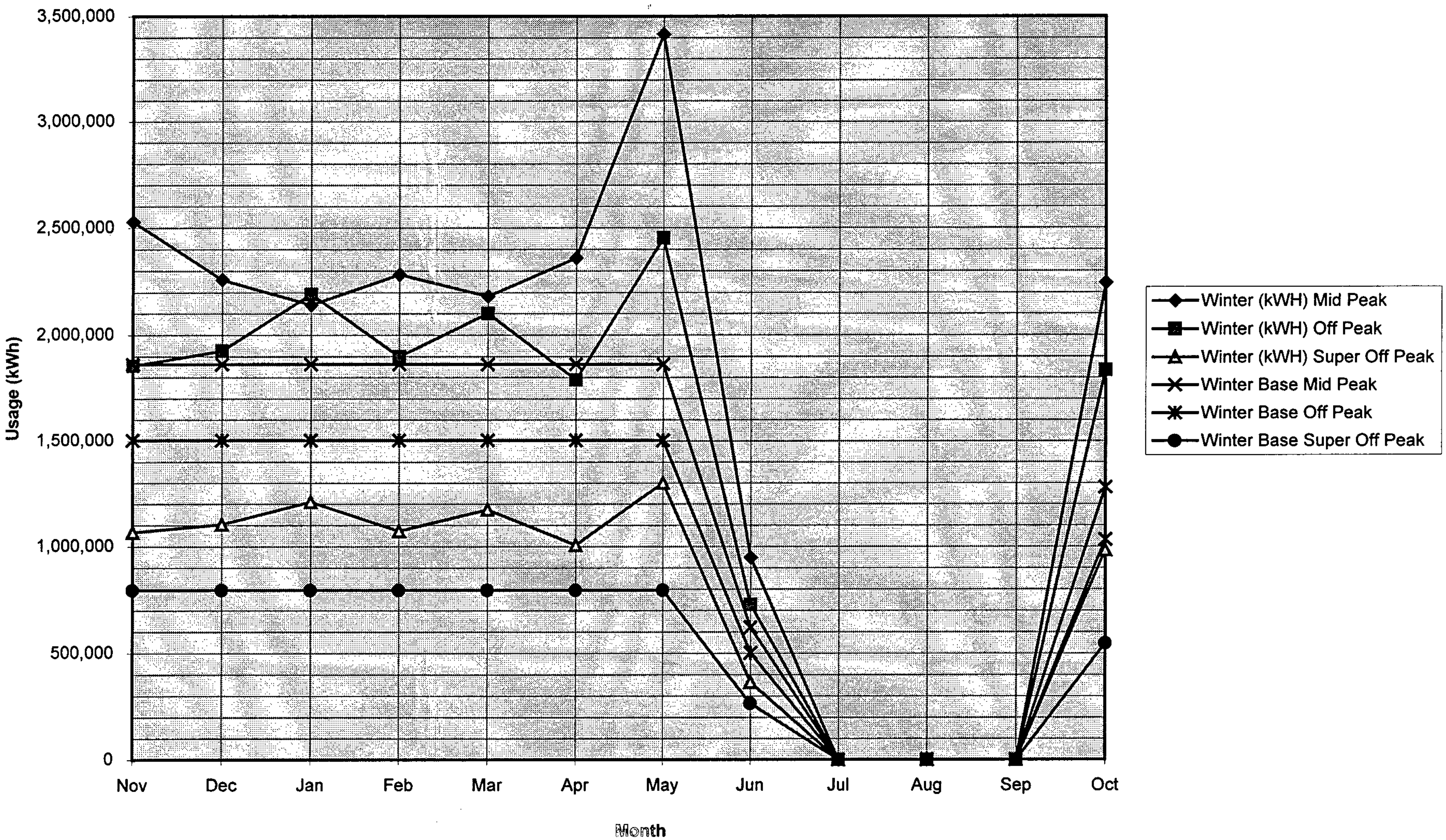


Figure D-3
FY1996 Summer Period Electric Power Usage and Base Quantities
Fort Irwin, California

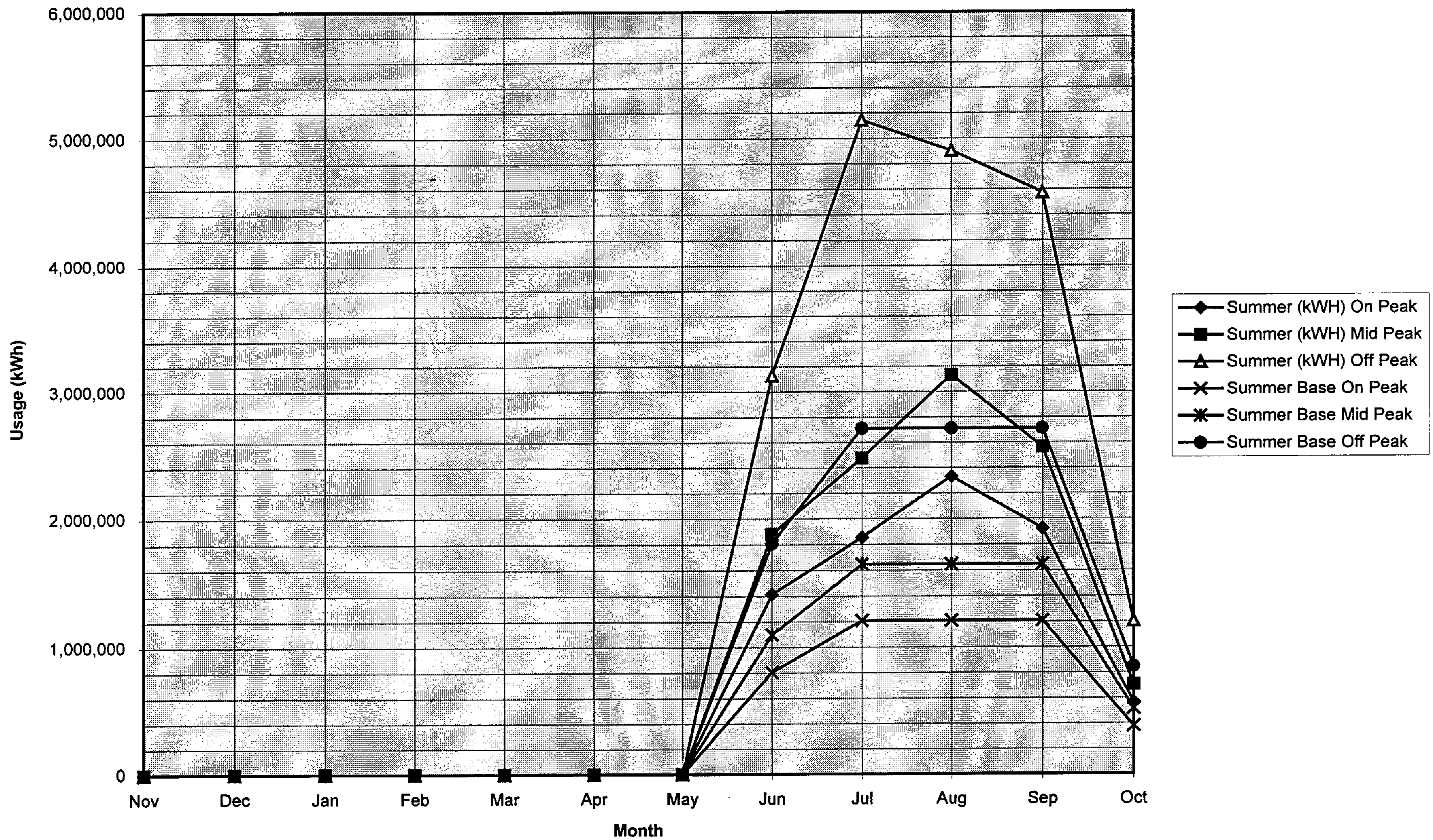


Figure D-4
FY1996 Winter Period Electric Power Demand and Base Quantities
Fort Irwin, California

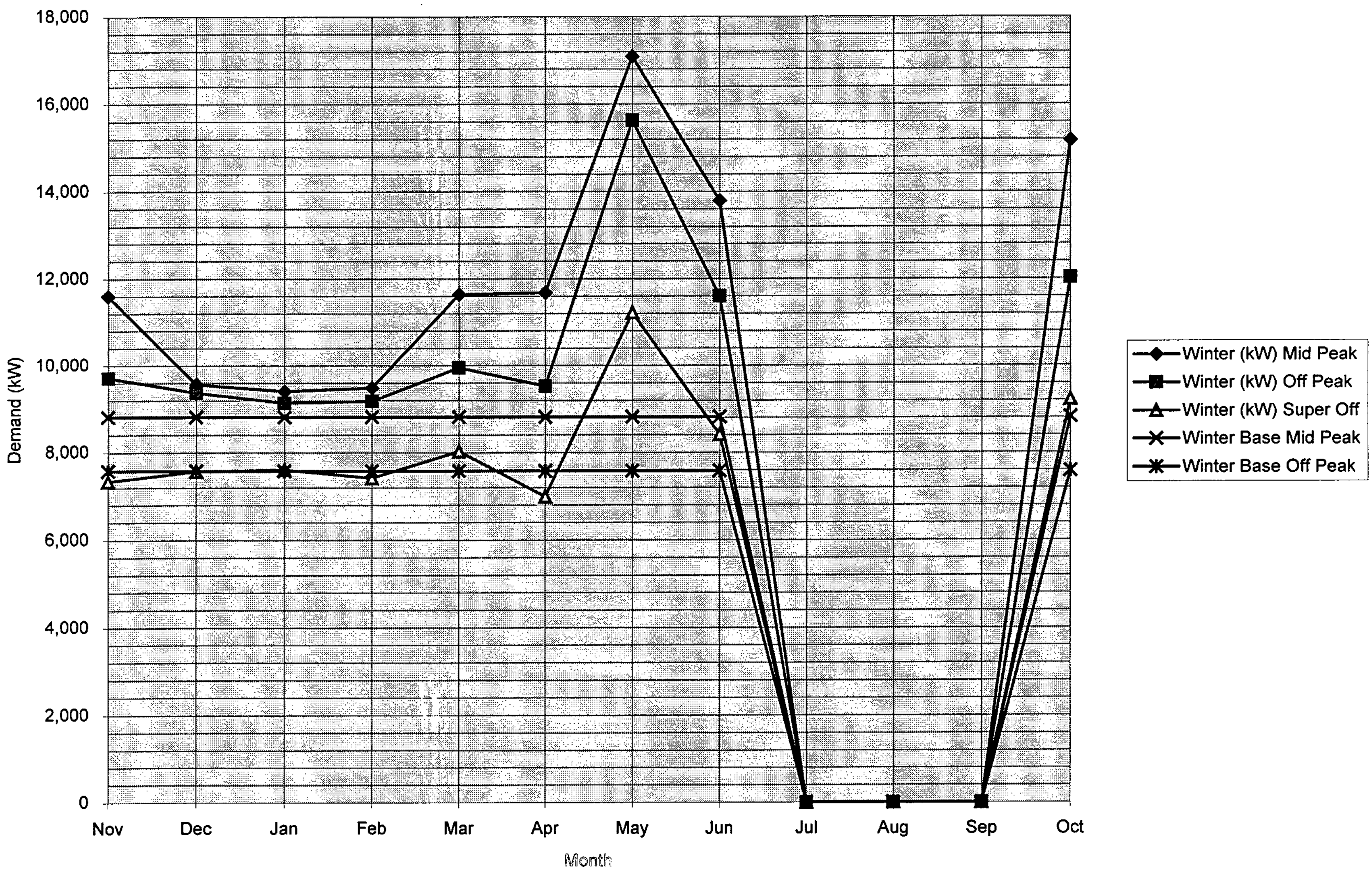


Figure D-5
FY1996 Summer Period Electric Power Demand and Base Quantities
Fort Irwin, California

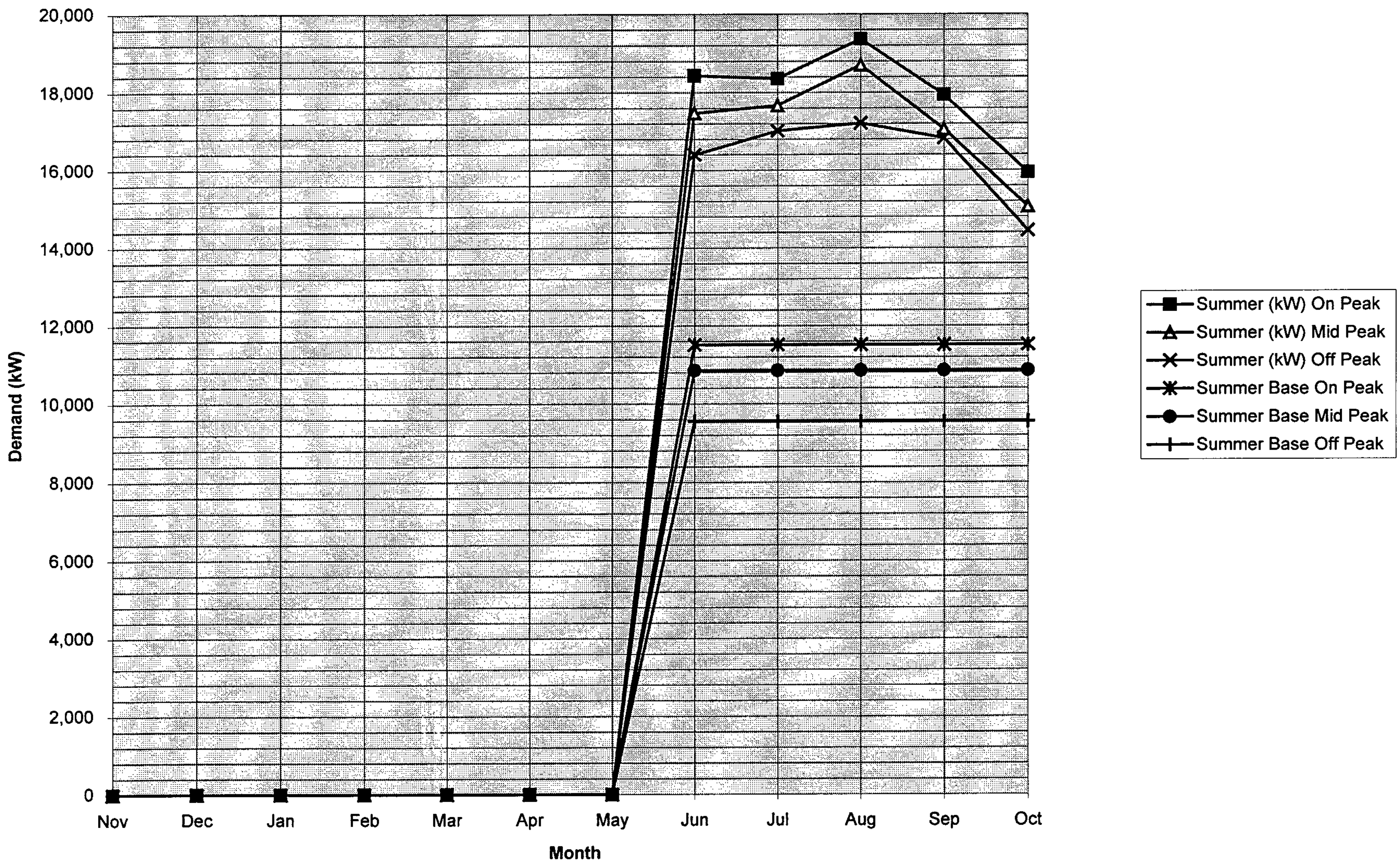
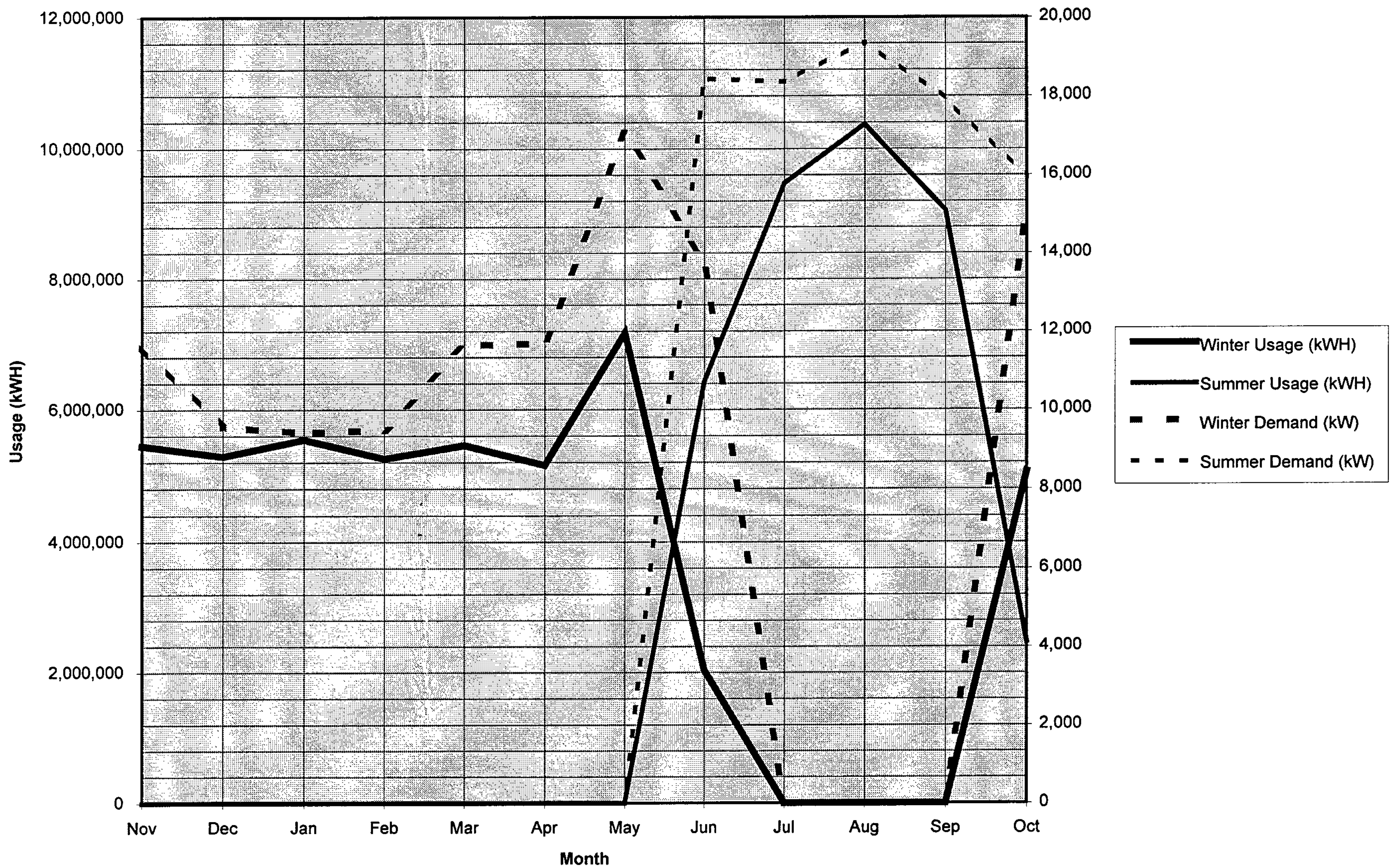


Figure D-6

FY1996 Total Electric Power Usage for Summer & Winter Periods, Fort Irwin, California



F:\PROJ\1640321\ENGR\RATES.XLS Billings Chart 5

Table D-1
Percentage kWh Savings Required to Achieve Base Level

Dates of FY1996 Service	Month	Winter			Summer		
		Mid Peak	Off Peak	Super Off	On Peak	Mid Peak	Off Peak
10/23 - 11/21	Nov	26.3%	19.1%	25.4%	NA	NA	NA
11/21 - 12/21	Dec	17.5%	22.0%	28.0%	NA	NA	NA
12/21 - 1/23	Jan	13.0%	31.4%	34.3%	NA	NA	NA
1/23 - 2/22	Feb	18.4%	20.9%	25.9%	NA	NA	NA
2/22 - 3/25	Mar	25.0%	28.5%	32.3%	NA	NA	NA
3/25 - 4/23	Apr	13.1%	16.1%	21.1%	NA	NA	NA
4/23 - 5/22	May	45.5%	38.8%	38.9%	NA	NA	NA
5/22 - 6/21	Jun	34.5%	31.1%	27.6%	43.0%	41.6%	42.3%
6/21 - 7/22	Jul	NA	NA	NA	34.8%	33.5%	47.3%
7/22 - 8/21	Aug	NA	NA	NA	48.2%	47.5%	44.7%
8/21 - 9/20	Sep	NA	NA	NA	25.5%	35.7%	40.7%
9/21 - 10/23	Oct	42.9%	43.7%	44.3%	33.0%	26.9%	29.5%
Total		26.9%	28.2%	31.3%	38.2%	39.1%	43.1%

Table D-2
Percentage kW Savings Required to Achieve Base Level

Dates of FY1996 Service	Month	Winter			Summer		
		Mid Peak	Off Peak	Super Off	On Peak	Mid Peak	Off Peak
10/23 - 11/21	Nov	24.0%	22.0%	100.0%	NA	NA	NA
11/21 - 12/21	Dec	7.8%	19.1%	100.0%	NA	NA	NA
12/21 - 1/23	Jan	6.3%	17.1%	100.0%	NA	NA	NA
1/23 - 2/22	Feb	7.1%	17.5%	100.0%	NA	NA	NA
2/22 - 3/25	Mar	39.1%	23.8%	100.0%	NA	NA	NA
3/25 - 4/23	Apr	24.5%	20.4%	100.0%	NA	NA	NA
4/23 - 5/22	May	48.4%	51.5%	100.0%	NA	NA	NA
5/22 - 6/21	Jun	36.1%	34.7%	100.0%	37.5%	37.9%	41.7%
6/21 - 7/22	Jul	NA	NA	NA	37.3%	38.5%	43.8%
7/22 - 8/21	Aug	NA	NA	NA	40.5%	41.9%	44.5%
8/21 - 9/20	Sep	NA	NA	NA	35.8%	36.3%	43.2%
9/21 - 10/23	Oct	41.9%	37.0%	100.0%	27.8%	27.9%	33.8%

APPENDIX E

Detailed Project Calculations, Construction Cost Estimates and Life-Cycle Cost Analyses

APPENDIX E
Table of Contents

Computed By:	BIH	**RECLAIM DOMESTIC WATER**	**Project:**	Water Conservation Study, Fort Irwin
Checked By:	RCL	**SYSTEM FLUSHING &**		
Date:	17 Feb '97	**FIRE HYDRANT TEST WATER**	**Project No.**	16-403-21
Revision:			**Sheet No.**	1 of 4

Background

Fire hydrants are flowed annually in order to perform residual pressure tests. Additionally, a number of hydrants are allowed to flush in order to clear the lines of accumulated silt. According to water system operators, each flush is performed for a period of 20 minutes with at least a 2-1/2-inch diameter port opened to 100%. Measurements of fire hydrant residual pressures require no more than a few minutes of flow.

The residual pressure testing and system flush water are presently allowed to flow to the storm drainage system. There are some 309 fire hydrants serving Fort Irwin, of which only 10 are listed as out of service. Thus; water losses from these activities are significant.

Proposed Water & Energy Conservation Retrofit

It is proposed to collect domestic water distribution system flush water and water from fire hydrant residual pressure tests in water trucks for use in irrigation and/or for dust control. Water is presently dispensed from water trucks for these purposes, thus, the "saved" water represents a true savings.

Domestic water system flush water can be flowed through fire hoses directly into top loading manholes of water trucks. Sand and silt collected in the water truck tanks can be removed by using much less flushing water than is flowed from hydrants.

In order to collect fire hydrant residual pressure testing flow water, it will be necessary to modify the hydrant testing procedure to flow the hydrant into a water truck. This might best be accomplished by connecting a fire hose to the hydrant and directing the flow from the hose into the large opening on top of the water tank. Flow measurements could be taken at this location with a stream straightener directed into the water truck top opening. Alternately, a pitot tube could be fitted into a custom pipe spool attached to a top loading fitting on the water truck. A pressure gage could also be fitted onto the spool, allowing residual pressure and flow measurements to be accomplished more efficiently.

While NFPA 291, paragraph 2-5 and 2-6 discuss pitot tube flow velocity measurements directly from the fire hydrant 2-1/2-inch barrel butt, testing at hose ends, if of the same configuration as the hydrant butt should be valid. Alternately, the provisions of paragraph 2-9, Determination of Discharge Without a Pitot, should be considered. Use of this method requires installation of a pressure gauge on one of the non-flowing hydrant caps.

The proposed project will require:

1. Fabrication of six (6) custom pipe spools as described above. Six assemblies are provided to allow for residual pressure tests when multiple hydrants must be flowed.
2. Additional administrative time to plan logistics of requiring water trucks to be scheduled along with hydrant testing crews and to identify areas needing irrigation and/or for dust control.

COMPUTATION SHEET

Keller & Gannon
Engineers Architects
Since 1941

Computed By:	BIH	**RECLAIM DOMESTIC WATER**	**Project:**	Water Conservation
Checked By:	RCL	**SYSTEM FLUSHING &**		Study, Fort Irwin
Date:	17 Feb '97	**FIRE HYDRANT TEST WATER**	**Project No.**	16-403-21
Revision:	April '97		**Sheet No.**	2 of 4

Estimated Water Consumption from Annual Flushing from Hydrants

Water flushing for 20 minutes each per active hydrant is estimated:

Number of flushing hydrants:	50	Assumed points to clear piping of accumulated silt
Port Size Used for Flush:	2.5	inches diameter
Static Pressure in Supply Pipe:	60	psig, assumed average of 80 psig supply from P-140
Flow Rate through Port:	834	gpm
Duration of Each Flushing:	20	minutes

Based on residual pressure of 20 psi (a very conservative value), the generally recommended minimum pressure for fire flow per NFPA 291, paragraph 2-1. Flow from NFPA 291, Table 2-10.1.

Annual total flush water: 834,000 gallons, or 16,680 gallons per flushing hydrant

From the previous sheet, each flushing is estimated to require 16,680 gallons of water.
Water trucks each hold about 4,000 gallons, thus, about 4 tank truck loads, with spillage

Estimated Water Consumption from Residual Pressure Testing of Hydrants

Water flushing for active hydrant is estimated:

Number of hydrants flowed:	299	Assumed points
Port Size Used for Flush:	2.5	inches diameter
Static Pressure in Supply Pipe:	60	psig, assumed average of 80 psig supply from P-140

(60 psig is used to allow for 20 psi drop during test and to provide a more conservative analysis)

Flow Rate through Port:	834	gpm
Duration of Each Flushing:	3	minutes

Based on residual pressure of 20 psi (a very conservative value), the generally recommended minimum pressure for fire flow per NFPA 291, paragraph 2-1. Flow from NFPA 291, Table 2-10.1.

Annual total flush water: 748,098 gallons, or 2,502 gallons per flowing hydrant

No more than a single water truck load is, thus, required per hydrant for residual pressure testing.

Total water usage from hydrant residual pressure testing and water system flushing:
1,582,098 gallons per year

Custom Pipe Spool Fabrication Costs

Each of six tools is assumed to cost $250 for fabrication in a custom plumbing shop
Total cost, with mark-up $1,875

COMPUTATION SHEET

Keller & Gannon
Engineers Architects
Since 1941

Computed By:	BIH	**RECLAIM DOMESTIC WATER**	**Project:**	Water Conservation
Checked By:	RCL	**SYSTEM FLUSHING &**		Study, Fort Irwin
Date:	17 Feb '97	**FIRE HYDRANT TEST WATER**	**Project No.**	16-403-21
Revision:	April '97		**Sheet No.**	3 of 4

Water Production O&M and Energy Cost Savings

From calculations of Domestic Water Costs:

Cost per 100 cubic feet = $0.4064 $0.5433 per 1000 Gallons

Component Costs:

Electric Demand:	$0.2398	/1000 gallons	
Electric Use:	$0.1783	/1000 gallons	
O&M:	$0.1252	/1000 gallons	(25% Allowance For Avoided Labor Costs)

Total Water Saved	1,582 thousand gallons/year		$860 per year saved, or	
Electric Demand Savings:	$379	/Yr Saved =	2.34 kW Saved @	$161.80 /kW-Year
Electric Use Savings:	$282	/Yr Saved =	5,232 kWH Saved @	$0.05393 /kWH
Water System O&M Savings:	$198	/Yr Saved		

Additional O&M and Administrative Costs

As stated in the previous sheet, extra efforts will be required to manage collection of the water system flushing and hydrant testing flows. Water system maintenance supervisors will have to arrange to have a water truck present when flushing. Fire fighters will have to coordinate in a similar fashion.

For system flushing, no added administrative costs are expensed as water trucks would be a normal component of the crew. Fire hydrant residual flow testing will require extra coordination as fire fighters and water system personnel will need to coordinate with each other.

The only extra costs are management costs to coordinate hydrant testing, irrigation and dust control logistics.

Assume, once a procedure is developed and used, that coordination time required per water truck load of 4,000 gallons is 5 minutes of a supervisory level person.

Hydrant Flowing:	206 loads per year		17 Hours/Year
Supervisory level personnel	$35 /Hour x	17 Hours/Year =	$600 per Year

Overall Non-Energy Savings

Water System O&M Savings	$198 per Year
Additional Management Costs	($600) per Year
Total Non-Energy Cost Savings	($402) per Year

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)

Location: Fort Irwin, California | Region No. 4 | Project No. PN 351
Project Title: FY96 Water Conservation Study | Fiscal Year FY96
Discrete Portion: Reclaim System Flush & Fire Hydrant Test Water | Preparer: KELLER & GANNON
Analysis Date: February, 1997 (Rev. April '97) | Economic Life: 20 Years

1. Investment Costs

A. Construction Costs		$1,875		
B. SIOH	5.5%	$103		
C. Design Cost	6.0%	$113		
D. Total Cost (1A+1B+1C)		$2,091		
E. Salvage Value of Existing Equipment			$0	
F. Public Utility Company Rebate			$0	
G. Total Investment (1D-1E-1F)				$2,091

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-11 Used for Discount Factors: July 1996

Energy Source	Cost $/MBTU	Saving MBTU/Yr(2)		Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$15.80	18		$282	15.03	$4,241
B. Dist					17.48	$0
C. Natural Gas					15.81	$0
D. Propane					15.81	$0
E. Demand Saving	$161.80	2.34	kW	$379	15.03	$5,702
F. Total				$662		$9,943

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($402)		
(1) Discount Factor (Table A)		14.34	
(2) Discounted Savings/Cost (3A x 3A1)			($5,765)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.		0		$0
b.				
c.				
d. Total	$0			$0

C Total Non Energy Discounted Savings (3A2+3Bd4) ($5,765)

4. First Year Dollar Savings (2F3+3A+(3Bd1/Economic Life)): $260
5. Simple Payback (1G/4): 8.06 Years
6. Total Net Discounted Savings (2F5+3C): $4,178
7. Savings to Investment Ratio (SIR) 5/1G: 2.00

NFPA 291

Recommended Practice for

Fire Flow Testing and Marking of Hydrants

1995 Edition

This edition of NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*, was prepared by the Technical Committee on Private Water Supply Piping Systems and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 22-25, 1995, in Denver, CO. It was issued by the Standards Council on July 21, 1995, with an effective date of August 11, 1995, and supersedes all previous editions.

This edition of NFPA 291 was approved as an American National Standard on August 11, 1995.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 291

The NFPA Committee on Public Water Supplies for Private Fire Protection presented the idea of indicating the relative available fire service water supply from hydrants in its 1934 report. The Committee felt then and feels now that such an indication is of substantial value to water and fire departments. The following recommendations were initially adopted in 1935. The Committee agreed that tests of individual hydrants did not give as complete and satisfactory results as group testing but expressed the opinion that tests of individual hydrants did have sufficient value to make the following recommendations worthy of adoption. This was reconfirmed with minor editorial changes in 1974.

The 1977 edition was completely rewritten and a chapter on the flow testing of hydrants was added.

The 1982 edition had been reconfirmed by the committee. The 1988 edition of the document noted several changed which clarified and reinforced certain recommendations. Specific guidance was added on the correct method of utilizing a Pitot tube to gain accurate test results.

The 1995 edition incorporated several changes in an attempt to make the document more user friendly. Changes were also incorporated with regard to the layout of hydrant and water flow tests.

Technical Committee on Private Water Supply Piping Systems

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Mid Hudson Automatic Sprinkler Corp., NY
Rep. Nat'l Fire Sprinkler Assn.

David S. Mowrer, *Vice Chair*
HSB Professional Loss Control Inc., TN

Kerry M. Bell, Underwriters Laboratories Inc., IL
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Milosh T. Puchovsky, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

NOTE: Membership on a Committee shall not in and of itself constitute an endorsement of the Association or any document developed by the Committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on private piping systems supplying water for fire protection and for hydrants, hose houses, and valves. The Committee is also responsible for documents on fire flow testing and marking of hydrants.

Contents

NFPA 291

Recommended Practice for

Fire Flow Testing and Marking of Hydrants

1995 Edition

Chapter 1 General Information

1-1 Introduction. Fire flow tests are conducted on water distribution systems to determine the rate of flow available at various locations for fire-fighting purposes. A certain residual pressure in the mains is specified at which the rate of flow should be available. Additional benefit is derived from fire flow tests by the indication of possible deficiencies (such as tuberculation of piping or closed valves or both) which could be corrected to ensure adequate fire flows as needed.

1-2 Definitions.

Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

Listed. Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Rated Capacity. The flow available from a hydrant at the designated residual pressure (rated pressure), either measured or calculated.

Residual Pressure. The pressure that exists in the distribution system, measured at the residual hydrant at the time the flow readings are taken at the flow hydrants.

Should. Indicates a recommendation or that which is advised but not required.

Static Pressure. The pressure that exists at a given point under normal distribution system conditions measured at the residual hydrant with no hydrants flowing.

1-3 Units. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table 1-3 with conversion factors.

Table 1-3

Name of Unit	Unit Symbol	Conversion Factor
liter	L	1 gal = 3.785 L
liter per minute per square meter	(L/min)/m²	1 gpm ft² = (40.746 L min)/m²
cubic decimeter	dm³	1 gal = 3.785 dm³
Pascal	Pa	1 psi = 6894.757 Pa
bar	bar	1 psi = 0.0689 bar
bar	bar	1 bar = 10^5 Pa

For additional conversions and information, see ASTM E380-1989, *Standard for Metric Practice.*

1-3.1 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first valve stated is to be regarded as the requirement. A given equivalent value might be approximate.

Chapter 2 Flow Testing

2-1 Rating Pressure. For the purpose of uniform marking of fire hydrants, the ratings should be based on a residual pressure of 20 psi (1.4 bar) for all hydrants having a static pressure in excess of 40 psi (2.8 bar). Hydrants having a static pressure of less than 40 psi (2.8 bar) should be rated at one-half of the static pressure.

It is generally recommended that a minimum residual pressure of 20 psi (1.4 bar) be maintained at hydrants when delivering the fire flow. Fire department pumpers can be operated where hydrant pressures are less, but with difficulty. Where hydrants are well distributed and of the proper size and type (so that friction losses in the hydrant and suction line are not excessive), it might be possible to set a lesser pressure as the minimum pressure. A primary concern should be the ability to maintain sufficient residual pressure to prevent developing a negative pressure at any point in the street mains, which could result in the collapse of the mains or other water system components or backsiphonage of polluted water from some other interconnected source. It should be noted that the use of residual pressures of less than 20 psi (1.4 bar) is not permitted by many state health departments.

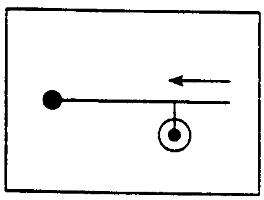
2-2 Procedure. Tests should be made during a period of ordinary demand. The procedure consists of discharging water at a measured rate of flow from the system at a given location and observing the corresponding pressure drop in the mains.

2-3 Layout of Test. After the location where the test is to be run has been determined, a group of test hydrants in the vicinity is selected. Once selected, due consideration

should be given to potential interference with traffic flow patterns, damage to surroundings (e.g., roadways, sidewalks, landscapes, vehicles, and pedestrians), and potential flooding problems both local and remote from the test site. One hydrant, designated the residual hydrant, is chosen to be the hydrant where the normal static pressure will be observed with the other hydrants in the group closed, and where the residual pressure will be observed with the other hydrants flowing. This hydrant is chosen so it will be located between the hydrant to be flowed and the large mains that constitute the immediate sources of water supply in the area. In Figure 2-3, a test layout is indicated, showing the residual hydrant by means of a circle.

The number of hydrants to be used in any test depends upon the strength of the distribution system in the vicinity of the test location. To obtain satisfactory test results of theoretical calculation of expected flows or rated capacities, sufficient discharge should be achieved to cause a drop in pressure at the residual hydrant of at least 25 percent, or to flow the total demand necessary for fire-fighting purposes. If the mains are small and the system weak, only one or two hydrants need to be flowed. If, on the other hand, the mains are large and the system strong, it may be necessary to flow as many as seven or eight hydrants.

It is preferable to flow water past the residual hydrant.



Note: Circles drawn about residual hydrant.
Arrow denotes flow direction in main.

Figure 2-3 Suggested test layout for hydrants.
(Copyright, Insurance Services Office, 1963)

2-4 Equipment. The equipment necessary for field work consists of a single 200-psi (14-bar) bourdon pressure gauge with 1-psi (0.0689 bar) graduations, a number of Pitot tubes, hydrant wrenches, 50- or 60-psi (3.5- or 4.0-bar) bourdon pressure gauges with $\frac{1}{2}$-psi (0.03445 bar) graduations, and scales with $\frac{1}{16}$-in. (1.6-mm) graduations (one Pitot tube, a 50- or 60-psi [3.5- or 4.0-bar] gauge, a hydrant wrench, and a scale for each hydrant to be flowed), and a special hydrant cap tapped with a hole into which a short length of $\frac{1}{4}$-in. (6.35-mm) brass pipe is fitted. This pipe is provided with a T connection for the 200-psi (14-bar) gauge and a cock at the end for relieving air pressure. All pressure gauges should be calibrated at least every 12 months, or more frequently depending on use. When more than one hydrant is flowed, it may be desirable and necessary to use portable radios to facilitate communication between team members.

It is preferred to use an Underwriter's Playpipe, or other stream straightener, when testing hydrants due to a more streamlined flow and more accurate pitot reading.

2-5 Test Procedure. In a typical test, the 200-psi (14 bar) gauge is attached to one of the $2\frac{1}{2}$-in. (6.4-cm) outlets of the residual hydrant using the special cap, the cock on the gauge piping is opened, and the hydrant valve is opened full. As soon as the air is exhausted from the barrel, the cock is closed. A reading (static pressure) is taken when the needle comes to rest. At a given signal each of the other hydrants is opened in succession, with discharge taking place directly from the open hydrant butts. Hydrants should be opened one at a time. With all hydrants flowing, water should be allowed to flow for a sufficient time to clear all debris and foreign substances from the stream(s). At that time, a signal is given to the people at the hydrants to read the Pitot pressure of the streams simultaneously while the residual pressure is being read. The final magnitude of the pressure drop can be controlled by the number of hydrants used and the number of outlets opened on each.

After the readings have been taken, hydrants should be shut down slowly, one at a time, to prevent undue surges in the system.

2-6 Pitot Readings. When measuring discharge from open hydrant butts, it is always preferable from the standpoint of accuracy to use $2\frac{1}{2}$-in. (6.4-cm) outlets rather than pumper outlets. In practically all cases, the $2\frac{1}{2}$-in. (6.4-cm) outlets are filled across the entire cross section during flow, while in the case of the larger outlets there is very frequently a void near the bottom. When measuring the Pitot pressure of a stream of practically uniform velocity, the orifice in the Pitot tube is held downstream approximately one-half the diameter of the hydrant outlet or nozzle opening, and in the center of the stream. The center line of the orifice should be at right angles to the plane of the face of the hydrant outlet. The air chamber on the Pitot tube should be kept elevated. Pitot readings of less than 10 psi (.7 bar) and more than 30 psi (2.0 bar) should be avoided, if possible. Opening additional hydrant outlets will aid in controlling the Pitot reading. With dry barrel hydrants, the hydrant valve should be wide open. This minimizes problems with underground drain valves. With wet barrel hydrants, the valve for the flowing outlet should be wide open. This gives a more streamlined flow and a more accurate Pitot reading. *(See Figure 2-6.)*

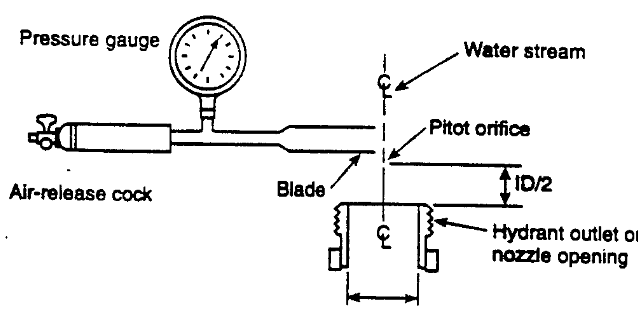


Figure 2-6 Pitot tube position.

2-7 Determination of Discharge. At the hydrants used for flow during the test, the discharges from the open butts are determined from measurements of the diameter of the outlets flowed, the pitot pressure (velocity head) of the streams as indicated by the Pitot gauge readings, and the coefficient of the outlet being flowed as determined from Figure 2-7. If flow tubes (stream straighteners) are being utilized, a coefficient of 0.95 is suggested unless the coefficient of the tube is known.

The formula used to compute the discharge, Q, in gpm from these measurements is:

$$Q = 29.83\ cd^2\sqrt{p} \qquad \text{(a)}$$

where c is the coefficient of discharge (*see Figure 2-7*), d the diameter of the outlet in inches, and p the pitot pressure (velocity head) in psi.

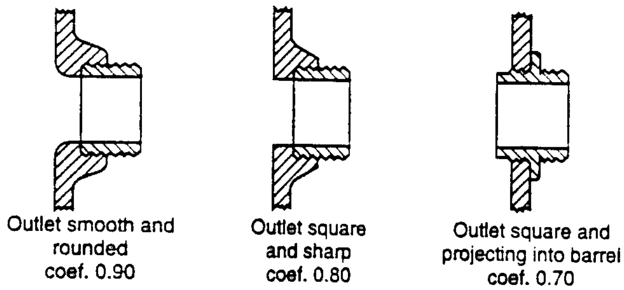


Figure 2-7 Three general types of hydrant outlets and their coefficients of discharge.

2-8 Use of Pumper Outlets. If it is necessary to use a pumper outlet, and flow tubes (stream straighteners) are not available, the best results are obtained with the pitot pressure (velocity head) maintained between 5 psi and 10 psi (.3 bar and .7 bar). For pumper outlets, the approximate discharge can be computed from equation (a) using the pitot pressure (velocity head) at the center of the stream and multiplying the result by one of the coefficients in Table 2-8, depending upon the pitot pressure (velocity head). These coefficients are applied in addition to the coefficient in equation (a) and are for average type hydrants.

Table 2-8 Pumper Outlet Coefficients

Pitot Pressure (Velocity Head)	Coefficient
2 psi (0.14 bar)	0.97
3 psi (0.21 bar)	0.92
4 psi (0.28 bar)	0.89
5 psi (0.35 bar)	0.86
6 psi (0.41 bar)	0.84
7 psi (0.48 bar) and over	0.83

2-9 Determination of Discharge Without a Pitot. If a Pitot tube is not available for use to measure the hydrant discharge, a 50- or 60-psi (3.5 or 4.0 bar) gauge tapped into a hydrant cap may be used. The hydrant cap with gauge attached is placed on one outlet, and the flow is allowed to take place through the other outlet at the same elevation. The readings obtained from a gauge so located, and the readings obtained from a gauge on a Pitot tube held in the stream, are approximately the same.

2-10 Calculation Results.

2-10.1 The discharge in gpm (L/min) for each outlet flowed is obtained from the discharge tables in 2-10.1 or by the use of formula (a). If more than one outlet is used, the discharges from all are added to obtain the total discharge.

The formula which is generally used to compute the discharge at the specified residual pressure or for any desired pressure drop is formula (b):

$$Q_R = Q_F \times \frac{h_r^{0.54}}{h_f^{0.54}} \qquad \text{(b)}$$

Q_R = flow predicted at desired residual pressure
Q_F = total flow measured during test
h_r = pressure drop to desired residual pressure
h_f = pressure drop measured during test

In this equation, any units of discharge or pressure drop may be used as long as the same units are used for each value of the same variable. In other words, if Q_R is expressed in gpm, Q_F must be in gpm, and if h_r is expressed in psi, h_f must be expressed in psi. These are the units which are normally used in applying formula (b) to fire flow test computations.

2-10.2 Discharge Calculations from Table. One means of solving this equation without the use of logarithms is by using Table 2-10.2. This table gives the values of the 0.54 power of the numbers from 1 to 175. Knowing the values of h_f, h_r, and Q_F, the values of $h_f^{0.54}$ and $h_r^{0.54}$ can be read from the table and formula (b) solved for Q_R. Results are usually carried to the nearest 100 gpm (380 L/min) for discharges of 1,000 gpm (3,800 L/min) or more, and to the nearest 50 gpm (190 L/min) for smaller discharges, which is as close as can be justified by the degree of accuracy of the field observations.

Method of Use

Insert in formula (b) the values of $h_r^{0.54}$ and $h_f^{0.54}$ determined from the table and the value of Q_F, and solve the equation of Q_R.

2-11 Data Sheet. The data secured during the testing of hydrants for uniform marking can be valuable for other purposes. With this in mind, it is suggested that the form shown in Figure 2-11 be used to record information that is taken. The back of the form should include a location sketch. When the tests are complete, the forms should be filed for future reference by interested parties.

2-12 System Corrections. It must be remembered that flow test results show the strength of the distribution system and do not necessarily indicate the degree of adequacy of the entire water works system. Consider a system supplied by pumps at one location and having no elevated storage. If the pressure at the pump station drops during the test, it is an indication that the distribution system is capable of delivering more than the pumps can deliver at their normal operating pressure. It is necessary to use a value for the drop in pressure for the test which is equal to the actual drop obtained in the field during the test, minus the drop in discharge pressure at the pumping station. If sufficient pumping capacity is available at the station and the discharge pressure could be maintained by operating additional pumps, the water system as a whole could deliver the computed quantity. If, however, additional pumping units are not available, the distribution system would be capable of delivering the computed quantity, but the water system as a whole would be limited by the pumping capacity. The portion of the pressure drop for which a correction can be made for tests on systems with storage is generally estimated upon the basis of a study of all the tests made and the pressure drops observed on the recording gauge at the station for each. The corrections may vary from very substantial portions of the observed pressure drops for tests near the pumping station, to zero for tests remote from the station.

Table 2-10.1 Theoretical Discharge Through Circular Orifices
(United States Gallons of Water per Minute)
(See Notes)

Pitot Pressure psi[1] (kPa)	Feet[2] (m)	Velocity Discharge, ft/sec (m/s)	2 (51)	2¼ (57)	2⅜ (60)	2½ (64)	2⅝ (67)	2¾ (70)	3 (76)	3¼ (83)	3½ (89)	3¾ (95)	4 (101)	4½ (114)
1 (6.89)	2.31 (0.70)	12.20 (3.72)	119 (451)	151 (571)	168 (637)	187 (705)	206 (778)	226 (854)	269 (1020)	315 (1190)	366 (1390)	420 (1590)	478 (1810)	604 (2290)
2 (13.8)	4.61 (1.41)	17.25 (5.26)	169 (639)	214 (808)	238 (900)	264 (1000)	291 (1100)	319 (1210)	380 (1440)	446 (1690)	517 (1960)	594 (2250)	676 (2560)	854 (3230)
3 (20.7)	6.92 (2.11)	21.13 (6.44)	207 (782)	262 (990)	292 (1100)	323 (1220)	356 (1350)	391 (1480)	465 (1760)	546 (2070)	633 (2400)	727 (2750)	827 (3130)	1045 (3960)
4 (27.6)	9.23 (2.81)	24.39 (7.43)	239 (930)	302 (1140)	337 (1280)	373 (1410)	411 (1560)	452 (1710)	537 (2030)	631 (2390)	731 (2770)	840 (3180)	955 (3610)	1210 (4570)
5 (34.5)	11.54 (3.52)	27.26 (8.31)	267 (1010)	338 (1280)	376 (1420)	417 (1580)	460 (1740)	505 (1910)	601 (2270)	705 (2670)	817 (3090)	938 (3550)	1068 (4040)	1350 (5110)
6 (41.4)	13.84 (4.22)	29.87 (9.10)	292 (1110)	370 (1400)	412 (1560)	457 (1730)	504 (1910)	553 (2090)	658 (2490)	772 (2920)	896 (3390)	1028 (3890)	1170 (4420)	1480 (5600)
7 (48.3)	16.15 (4.92)	32.26 (9.83)	316 (1190)	400 (1510)	445 (1680)	494 (1870)	544 (2060)	597 (2260)	711 (2690)	834 (3160)	967 (3660)	1111 (4210)	1263 (4780)	1600 (6050)
8 (55.2)	18.46 (5.63)	34.49 (10.51)	338 (1280)	427 (1620)	476 (1800)	528 (2000)	582 (2200)	638 (2410)	760 (2880)	892 (3380)	1034 (3910)	1187 (4490)	1351 (5110)	1710 (6470)
9 (62.0)	20.76 (6.33)	36.58 (11.15)	358 (1360)	453 (1710)	505 (1910)	560 (2120)	617 (2340)	677 (2560)	806 (3050)	946 (3580)	1097 (4150)	1259 (4770)	1433 (5420)	1815 (6860)
10 (68.9)	23.07 (7.03)	38.56 (11.75)	378 (1430)	478 (1810)	532 (2010)	590 (2230)	650 (2460)	714 (2700)	850 (3220)	997 (3770)	1156 (4380)	1327 (5020)	1510 (5710)	1910 (7230)
11 (75.8)	25.38 (7.73)	40.45 (12.33)	396 (1500)	501 (1900)	553 (2110)	619 (2340)	682 (2580)	759 (2830)	891 (3370)	1046 (3960)	1213 (4590)	1392 (5270)	1584 (5990)	2010 (7580)
12 (82.7)	27.68 (8.44)	42.24 (12.87)	414 (1560)	524 (1980)	583 (2210)	646 (2450)	712 (2690)	782 (2960)	931 (3520)	1092 (4130)	1267 (4800)	1454 (5500)	1655 (6260)	2100 (7920)
13 (89.6)	29.99 (9.14)	43.97 (13.40)	431 (1630)	545 (2060)	607 (2300)	673 (2550)	741 (2800)	814 (3080)	969 (3670)	1137 (4300)	1318 (4990)	1515 (5730)	1722 (6520)	2180 (8240)
14 (96.5)	32.30 (9.84)	45.63 (13.91)	447 (1690)	566 (2140)	630 (2380)	698 (2640)	769 (2910)	845 (3200)	1005 (3800)	1180 (4470)	1368 (5180)	1572 (5950)	1787 (6760)	2260 (8550)
15 (103)	34.61 (10.55)	47.22 (14.39)	463 (1750)	586 (2220)	652 (2470)	722 (2730)	796 (3010)	874 (3310)	1040 (3940)	1221 (4620)	1416 (5360)	1626 (6150)	1849 (7000)	2340 (8850)
16 (110)	36.91 (11.25)	48.78 (14.87)	478 (1810)	605 (2290)	673 (2550)	746 (2820)	822 (3110)	903 (3420)	1075 (4070)	1261 (4770)	1463 (5540)	1679 (6360)	1910 (7230)	2420 (9140)
17 (117)	39.22 (11.95)	50.28 (15.33)	493 (1870)	623 (2360)	694 (2630)	769 (2910)	848 (3210)	931 (3520)	1108 (4190)	1300 (4920)	1508 (5710)	1731 (6550)	1969 (7540)	2500 (9430)
18 (124)	41.53 (12.66)	51.73 (15.77)	507 (1920)	642 (2430)	714 (2700)	791 (2990)	872 (3300)	958 (3630)	1140 (4310)	1338 (5060)	1551 (5870)	1781 (6740)	2026 (7670)	2570 (9700)
19 (131)	43.83 (13.36)	53.15 (16.20)	521 (1970)	659 (2490)	733 (2770)	813 (3080)	896 (3390)	984 (3720)	1171 (4430)	1374 (5200)	1594 (6030)	1830 (6920)	2082 (7870)	2640 (9970)
20 (138)	46.14 (14.06)	54.54 (16.62)	534 (2020)	676 (2560)	753 (2850)	834 (3160)	920 (3480)	1010 (3820)	1201 (4540)	1410 (5330)	1635 (6180)	1877 (7100)	2136 (8080)	2710 (10200)
22 (152)	50.75 (15.47)	57.19 (17.43)	560 (2120)	709 (2680)	789 (2990)	875 (3310)	964 (3650)	1059 (4000)	1260 (4770)	1479 (5590)	1715 (6490)	1969 (7540)	2240 (8470)	2840 (10700)
24 (165)	55.37 (16.88)	59.74 (18.21)	585 (2210)	741 (2800)	824 (3120)	914 (3460)	1007 (3810)	1106 (4180)	1316 (4980)	1545 (5840)	1791 (6770)	2056 (7780)	2340 (8850)	2970 (11200)
26 (179)	59.98 (18.28)	62.18 (18.95)	609 (2300)	771 (2910)	858 (3250)	951 (3600)	1048 (3970)	1151 (4350)	1370 (5180)	1608 (6080)	1864 (7050)	2140 (8100)	2435 (9210)	3090 (11700)
28 (193)	64.60 (19.69)	64.52 (19.67)	632 (2390)	800 (3020)	890 (3370)	987 (3730)	1088 (4120)	1194 (4520)	1422 (5380)	1668 (6310)	1935 (7320)	2221 (8400)	2527 (9560)	3210 (12100)
30 (207)	69.21 (21.10)	66.79 (20.36)	654 (2470)	828 (3130)	922 (3490)	1022 (3860)	1126 (4260)	1236 (4680)	1472 (5570)	1727 (6530)	2003 (7570)	2299 (8700)	2616 (9890)	3320 (12500)
32 (221)	73.82 (22.50)	68.98 (21.03)	676 (2550)	856 (3230)	952 (3600)	1055 (3990)	1163 (4400)	1277 (4830)	1520 (5750)	1784 (6750)	2069 (7820)	2375 (8980)	2702 (10200)	3430 (12900)
34 (234)	78.44 (23.91)	71.10 (21.67)	697 (2640)	882 (3340)	981 (3710)	1088 (4120)	1199 (4540)	1316 (4980)	1566 (5930)	1838 (6960)	2132 (8070)	2448 (9270)	2785 (10540)	3540 (13300)
36 (248)	83.05 (25.31)	73.16 (22.30)	717 (2710)	908 (3440)	1010 (3820)	1119 (4240)	1233 (4670)	1354 (5120)	1612 (6100)	1892 (7160)	2194 (8300)	2519 (9530)	2866 (10850)	3640 (13800)

Table 2-10.1 Continued

Pitot Pressure psi[1] (kPa)	Feet[2] (m)	Velocity Discharge, ft/sec (m/s)	2 (51)	2¼ (57)	2⅜ (60)	2½ (64)	2⅝ (67)	2¾ (70)	3 (76)	3¼ (83)	3½ (89)	3¾ (95)	4 (101)	4½ (114)
38 (262)	87.67 (26.72)	75.17 (22.91)	736 (2790)	932 (3530)	1037 (3930)	1150 (4350)	1267 (4800)	1392 (5270)	1656 (6270)	1944 (7360)	2254 (8530)	2588 (9800)	2944 (11140)	3740 (14100)
40 (276)	92.28 (28.13)	77.11 (23.50)	755 (2860)	956 (3620)	1064 (4030)	1180 (4470)	1300 (4920)	1428 (5400)	1699 (6430)	1994 (7550)	2313 (8750)	2655 (10050)	3021 (11430)	3840 (14500)
42 (290)	96.89 (29.53)	79.03 (24.09)	774 (2930)	980 (3710)	1091 (4130)	1209 (4580)	1332 (5040)	1463 (5540)	1741 (6590)	2043 (7730)	2370 (8970)	2721 (10300)	3095 (11710)	3935 (14800)
44 (303)	101.51 (30.94)	80.88 (24.65)	792 (3000)	1003 (3800)	1116 (4220)	1237 (4680)	1364 (5160)	1497 (5670)	1782 (6740)	2091 (7910)	2426 (9180)	2785 (10540)	3168 (11990)	4030 (15200)
46 (317)	106.12 (32.35)	82.70 (25.21)	810 (3070)	1025 (3880)	1141 (4320)	1265 (4790)	1394 (5280)	1531 (5790)	1822 (6900)	2138 (8090)	2480 (9390)	2847 (10780)	3239 (12260)	4120 (15500)
48 (331)	110.74 (33.75)	84.48 (25.75)	828 (3130)	1047 (3960)	1166 (4410)	1293 (4890)	1424 (5390)	1564 (5920)	1861 (7040)	2184 (8270)	2533 (9587)	2908 (11010)	3309 (12520)	4205 (15800)
50 (345)	115.35 (35.16)	86.22 (26.28)	845 (3200)	1069 (4050)	1190 (4500)	1319 (4990)	1454 (5500)	1596 (6040)	1900 (7190)	2229 (8440)	2586 (9790)	2968 (11230)	3377 (12780)	4290 (16200)
52 (358)	119.96 (36.57)	87.93 (26.80)	861 (3260)	1091 (4130)	1213 (4590)	1345 (5090)	1482 (5610)	1628 (6160)	1937 (7330)	2274 (8610)	2637 (9980)	3027 (11460)	3444 (13040)	4375 (16500)
54 (372)	124.58 (37.97)	89.61 (27.31)	878 (3320)	1111 (4200)	1237 (4680)	1371 (5190)	1511 (5720)	1659 (6280)	1974 (7470)	2317 (8770)	2687 (10170)	3085 (11680)	3510 (13290)	4460 (16800)
56 (386)	129.19 (39.38)	91.20 (27.80)	894 (3380)	1132 (4280)	1259 (4770)	1396 (5280)	1538 (5820)	1689 (6390)	2010 (7610)	2359 (8930)	2736 (10360)	3141 (11890)	3574 (13530)	4540 (17100)
58 (400)	133.81 (40.78)	92.87 (28.31)	909 (3440)	1152 (4350)	1282 (4850)	1421 (5370)	1566 (5920)	1719 (6500)	2046 (7740)	2401 (9080)	2785 (10530)	3197 (12090)	3637 (13760)	4620 (17400)
60 (414)	138.42 (42.19)	94.45 (28.79)	925 (3500)	1171 (4430)	1303 (4930)	1445 (5460)	1592 (6030)	1749 (6610)	2081 (7870)	2442 (9240)	2832 (10710)	3252 (12300)	3700 (13990)	4700 (17700)
62 (427)	143.03 (43.60)	96.01 (29.26)	941 (3560)	1191 (4500)	1325 (5010)	1470 (5560)	1619 (6130)	1777 (6720)	2115 (8000)	2483 (9390)	2879 (10890)	3305 (12500)	3761 (14220)	4775 (18000)
64 (441)	147.65 (45.00)	97.55 (29.73)	956 (3610)	1210 (4570)	1346 (5090)	1493 (5640)	1645 (6220)	1806 (6830)	2149 (8130)	2522 (9540)	2925 (11060)	3358 (12700)	3821 (14450)	4850 (18300)
66 (455)	152.26 (46.41)	99.07 (30.20)	971 (3670)	1228 (4640)	1367 (5170)	1516 (5730)	1670 (6320)	1834 (6940)	2183 (8260)	2561 (9690)	2971 (11240)	3410 (12900)	3880 (14680)	4925 (18600)
68 (469)	156.88 (47.82)	100.55 (30.65)	985 (3720)	1247 (4710)	1388 (5250)	1539 (5820)	1695 (6420)	1862 (7040)	2215 (8380)	2600 (9830)	3015 (11400)	3462 (13090)	3938 (14900)	5000 (18900)
70 (483)	161.49 (49.22)	102.03 (31.10)	999 (3780)	1265 (4780)	1408 (5330)	1561 (5900)	1720 (6510)	1889 (7140)	2248 (8500)	2638 (9980)	3059 (11570)	3512 (13280)	3996 (15110)	5075 (19100)
72 (496)	166.10 (50.63)	103.47 (31.54)	1014 (3830)	1283 (4850)	1428 (5400)	1583 (5990)	1745 (6600)	1916 (7250)	2280 (8620)	2675 (10120)	3103 (11730)	3562 (13470)	4053 (15330)	5140 (19400)
74 (510)	170.72 (52.03)	104.90 (31.97)	1028 (3880)	1301 (4920)	1448 (5480)	1605 (6070)	1769 (6690)	1942 (7350)	2311 (8740)	2712 (10260)	3146 (11900)	3611 (13660)	4109 (15540)	5200 (19700)
76 (524)	175.33 (53.44)	106.30 (32.71)	1041 (3940)	1318 (4980)	1467 (5550)	1627 (6150)	1792 (6780)	1968 (7440)	2342 (8860)	2749 (10400)	3188 (12060)	3660 (13840)	4164 (15750)	5265 (19900)
78 (538)	179.95 (54.85)	107.69 (32.82)	1055 (3990)	1335 (5050)	1486 (5620)	1648 (6230)	1816 (6870)	1994 (7540)	2373 (8970)	2785 (10530)	3230 (12210)	3708 (14020)	4218 (15950)	5340 (20200)
80 (552)	184.56 (56.25)	109.08 (33.25)	1068 (4040)	1352 (5110)	1505 (5690)	1669 (6310)	1839 (6960)	2019 (7640)	2403 (9090)	2820 (10670)	3271 (12370)	3755 (14200)	4272 (16160)	5405 (20400)
82 (565)	189.17 (57.66)	110.42 (33.66)	1082 (4090)	1369 (5180)	1524 (5770)	1689 (6390)	1862 (7040)	2044 (7730)	2433 (9200)	2855 (10800)	3311 (12520)	3801 (14380)	4325 (16360)	5470 (20700)
84 (579)	193.79 (59.07)	111.76 (34.06)	1095 (4140)	1386 (5240)	1542 (5840)	1710 (6466)	1884 (7130)	2069 (7830)	2462 (9310)	2890 (10930)	3351 (12670)	3847 (14550)	4377 (16560)	5535 (21000)
86 (593)	198.40 (60.47)	113.08 (34.47)	1170 (4190)	1402 (5300)	1561 (5900)	1730 (6540)	1907 (7210)	2094 (7920)	2491 (9420)	2924 (11070)	3391 (12820)	3893 (14720)	4429 (16750)	5600 (21200)
88 (607)	203.02 (61.88)	114.39 (34.87)	1120 (4240)	1419 (5360)	1579 (5970)	1750 (6620)	1929 (7300)	2118 (8010)	2520 (9530)	2958 (11190)	3430 (12970)	3938 (14890)	4480 (16950)	5665 (21400)
90 (620)	207.63 (63.29)	115.68 (35.26)	1133 (4280)	1434 (5420)	1596 (6040)	1770 (6690)	1950 (7380)	2142 (8100)	2549 (9640)	2991 (11310)	3469 (13120)	3983 (15060)	4531 (17140)	5730 (21700)
92 (634)	212.24 (64.69)	116.96 (35.65)	1146 (4330)	1450 (5480)	1614 (6110)	1789 (6770)	1972 (7460)	2165 (8190)	2577 (9750)	3024 (11440)	3507 (13260)	4027 (15230)	4581 (17330)	5795 (21900)

Table 2-10.1 Continued

Pitot Pressure psi[1] (kPa)	Feet² (m)	Velocity Discharge, ft/sec (m/s)	2 (51)	2¼ (57)	2⅜ (60)	2½ (64)	2⅝ (67)	2¾ (70)	3 (76)	3¼ (83)	3½ (89)	3¾ (95)	4 (101)	4½ (114)
94	216.86	118.23	1158	1466	1632	1809	1993	2189	2605	3057	3545	4070	4631	5865
(648)	(66.10)	(36.04)	(4380)	(5540)	(6170)	(6840)	(7540)	(8280)	(9850)	(11560)	(13410)	(15390)	(17510)	(22200)
96	221.47	119.48	1170	1481	1649	1828	2014	2212	2632	3089	3583	4113	4680	5925
(662)	(67.50)	(36.42)	(4420)	(5600)	(6240)	(6910)	(7620)	(8370)	(9960)	(11680)	(13550)	(15560)	(17700)	(22400)
98	226.09	120.71	1182	1497	1666	1847	2035	2235	2660	3121	3620	4156	4728	5985
(676)	(68.91)	(36.79)	(4470)	(5660)	(6300)	(6980)	(7700)	(8450)	(10060)	(11810)	(13690)	(15720)	(17880)	(22600)
100	230.70	121.94	1194	1512	1683	1866	2056	2258	2687	3153	3657	4198	4776	6045
(689)	(70.32)	(37.17)	(4520)	(5720)	(6370)	(7050)	(7780)	(8540)	(10160)	(11930)	(13830)	(15880)	(18060)	(22900)
102	235.31	123.15	1206	1527	1699	1884	2076	2280	2713	3184	3693	4240	4824	6100
(703)	(71.72)	(37.54)	(4560)	(5770)	(6430)	(7130)	(7860)	(8620)	(10260)	(12040)	(13970)	(16040)	(18240)	(23100)
104	239.93	124.35	1218	1542	1716	1903	2097	2302	2740	3215	3729	4281	4871	6150
(717)	(73.13)	(37.90)	(4610)	(5830)	(6490)	(7190)	(7930)	(8710)	(10360)	(12160)	(14100)	(16190)	(18420)	(23300)
106	244.54	125.55	1230	1556	1733	1921	2117	2324	2766	3246	3765	4322	4917	6200
(731)	(74.54)	(38.27)	(4650)	(5890)	(6560)	(7260)	(8010)	(8790)	(10460)	(12280)	(14240)	(16350)	(18600)	(23500)
108	249.16	126.73	1241	1571	1749	1939	2137	2346	2792	3277	3800	4363	4963	6260
(745)	(75.94)	(38.63)	(4690)	(5940)	(6620)	(7330)	(8080)	(8870)	(10560)	(12390)	(14370)	(16500)	(18770)	(23800)
110	253.77	127.89	1253	1586	1765	1957	2156	2368	2818	3307	3835	4403	5009	6320
(758)	(77.35)	(38.98)	(4640)	(6000)	(6680)	(7400)	(8160)	(8960)	(10660)	(12510)	(14500)	(16650)	(18950)	(24000)
112	258.38	129.05	1264	1600	1781	1974	2176	2389	2843	3337	3870	4443	5054	6380
(772)	(78.76)	(39.33)	(4780)	(6050)	(6740)	(7470)	(8230)	(9040)	(10750)	(12620)	(14640)	(16800)	(19120)	(24200)
114	263.00	130.20	1275	1614	1797	1992	2195	2410	2869	3367	3904	4482	5099	6440
(786)	(80.16)	(39.68)	(4820)	(6100)	(6800)	(7530)	(8310)	(9120)	(10850)	(12730)	(14770)	(16950)	(19290)	(24400)
116	267.61	131.33	1286	1628	1812	2009	2214	2431	2894	3396	3938	4521	5144	6500
(800)	(81.57)	(40.03)	(4860)	(6160)	(6860)	(7600)	(8380)	(9200)	(10940)	(12840)	(14890)	(17100)	(19460)	(24600)
118	272.23	132.46	1297	1642	1828	2027	2233	2452	2918	3425	3972	4560	5188	6560
(813)	(82.97)	(40.37)	(4910)	(6210)	(6920)	(7660)	(8450)	(9280)	(11040)	(12950)	(15020)	(17250)	(19620)	(24800)
120	276.84	133.57	1308	1656	1843	2044	2252	2473	2943	3454	4006	4599	5232	6620
(827)	(84.38)	(40.71)	(4950)	(6260)	(6970)	(7730)	(8520)	(9350)	(11130)	(13060)	(15150)	(17390)	(19790)	(25000)
122	281.45	134.69	1319	1670	1859	2061	2271	2494	2967	3483	4039	4637	5275	6680
(841)	(85.79)	(41.05)	(4990)	(6310)	(7030)	(7790)	(8590)	(9430)	(11220)	(13170)	(15270)	(17540)	(19950)	(25300)
124	286.07	135.79	1330	1684	1874	2077	2289	2514	2992	3511	4072	4675	5318	6740
(855)	(87.19)	(41.39)	(5030)	(6370)	(7090)	(7860)	(8660)	(9510)	(11320)	(13280)	(15400)	(17680)	(20120)	(25500)
126	290.68	136.88	1341	1697	1889	2094	2308	2534	3016	3539	4105	4712	5361	6800
(869)	(88.60)	(41.72)	(5070)	(6420)	(7150)	(7920)	(8730)	(9580)	(11410)	(13390)	(15520)	(17820)	(20280)	(25700)
128	295.30	137.96	1351	1711	1904	2111	2326	2554	3040	3567	4137	4749	5403	6850
(882)	(90.01)	(42.05)	(5110)	(6470)	(7200)	(7980)	(8800)	(9660)	(11500)	(13490)	(15650)	(17960)	(20440)	(25900)
130	299.91	139.03	1362	1724	1919	2127	2344	2574	3063	3595	4169	4786	5445	6900
(896)	(91.41)	(42.38)	(5150)	(6520)	(7260)	(8040)	(8870)	(9740)	(11590)	(13600)	(15770)	(18100)	(20600)	(26100)
132	304.52	140.10	1372	1736	1933	2144	2362	2594	3087	3623	4201	4823	5487	6950
(910)	(92.82)	(42.70)	(5190)	(6570)	(7320)	(8110)	(8940)	(9810)	(11670)	(13700)	(15890)	(18240)	(20750)	(26300)
134	309.14	141.16	1382	1749	1948	2160	2380	2613	3110	3650	4233	4860	5529	7000
(924)	(94.23)	(43.03)	(5230)	(6620)	(7370)	(8170)	(9010)	(9880)	(11760)	(13800)	(16010)	(18380)	(20910)	(26500)
136	313.75	142.21	1392	1762	1962	2176	2398	2633	3133	3677	4625	4896	5570	7050
(938)	(95.63)	(43.35)	(5270)	(6670)	(7430)	(8230)	(9070)	(9960)	(11850)	(13910)	(16130)	(18520)	(21070)	(26700)

[1] 1 psi—2.307 ft of water, 1 kPa—0.102 m of water. For pressure in bars, multiply by 0.01.

Notes to Table 2-10.1

Note 1. This corresponds to velocity head.

Note 2. This table is computed from the formula $Q = 29.83cd^2\sqrt{p}$ ($Q_m = 0.0666cd^2\sqrt{p_m}$) with $c = 1.00$. The theoretical discharge of sea water, as from fire-boat nozzles, can be found by subtracting 1 percent from the figures in the following table, or from the formula $Q = 29.83cd^2\sqrt{p}$ ($Q_m = 0.065cd^2m\ p_m$).

Appropriate coefficient should be applied where it is read from hydrant outlet. Where more accurate results are required, a coefficient appropriate on the particular nozzle must be selected and applied to the figures of the table.

The discharge from circular openings of sizes other than those in the table can readily be computed by applying the principle that quantity discharged under a given head varies as the square of the diameter of the opening.

Table 2-10.2 Values of "h" to the 0.54 Power

h	$h^{0.54}$	h	$h^{0.54}$	h	$h^{0.54}$	h	$h^{0.54}$	h	$h^{0.54}$
1	1.00	36	6.93	71	9.99	106	12.41	141	14.47
2	1.45	37	7.03	72	10.07	107	12.47	142	14.53
3	1.81	38	7.13	73	10.14	108	12.53	143	14.58
4	2.11	39	7.23	74	10.22	109	12.60	144	14.64
5	2.39	40	7.33	75	10.29	110	12.66	145	14.69
6	2.63	41	7.43	76	10.37	111	12.72	146	14.75
7	2.86	42	7.53	77	10.44	112	12.78	147	14.80
8	3.07	43	7.62	78	10.51	113	12.84	148	14.86
9	3.28	44	7.72	79	10.59	114	12.90	149	14.91
10	3.47	45	7.81	80	10.66	115	12.96	150	14.97
11	3.65	46	7.91	81	10.73	116	13.03	151	15.02
12	3.83	47	8.00	82	10.80	117	13.09	152	15.07
13	4.00	48	8.09	83	10.87	118	13.15	153	15.13
14	4.16	49	8.18	84	10.94	119	13.21	154	15.18
15	4.32	50	8.27	85	11.01	120	13.27	155	15.23
16	4.48	51	8.36	86	11.08	121	13.33	156	15.29
17	4.62	52	8.44	87	11.15	122	13.39	157	15.34
18	4.76	53	8.53	88	11.22	123	13.44	158	15.39
19	4.90	54	8.62	89	11.29	124	13.50	159	15.44
20	5.04	55	8.71	90	11.36	125	13.56	160	15.50
21	5.18	56	8.79	91	11.43	126	13.62	161	15.55
22	5.31	57	8.88	92	11.49	127	13.68	162	15.60
23	5.44	58	8.96	93	11.56	128	13.74	163	15.65
24	5.56	59	9.04	94	11.63	129	13.80	164	15.70
25	5.69	60	9.12	95	11.69	130	13.85	165	15.76
26	5.81	61	9.21	96	11.76	131	13.91	166	15.81
27	5.93	62	9.29	97	11.83	132	13.97	167	15.86
28	6.05	63	9.37	98	11.89	133	14.02	168	15.91
29	6.16	64	9.45	99	11.96	134	14.08	169	15.96
30	6.28	65	9.53	100	12.02	135	14.14	170	16.01
31	6.39	66	9.61	101	12.09	136	14.19	171	16.06
32	6.50	67	9.69	102	12.15	137	14.25	172	16.11
33	6.61	68	9.76	103	12.22	138	14.31	173	16.16
34	6.71	69	9.84	104	12.28	139	14.36	174	16.21
35	6.82	70	9.92	105	12.34	140	14.42	175	16.26

Hydrant Flow Test Report

Location ______________________ Date __________

Test made by ______________________ Time ________ .M.

Representative of ______________________

Witness ______________________

State purpose of test ______________________

____

Consumption rate during test ______________________

If pumps affect test, indicate pumps operating ______________________

Flow hydrants: ____ A_1 ____ A_2 ____ A_3 ____ A_4 ____

Size nozzle ______________________

Pitot reading ______________________

Discharge coefficient ______________________ Total GPM

GPM ______________________

Static B ________ psi Residual B ________ psi

Projected results @20 psi Residual ____ gpm; or @____ psi Residual ____ gpm

Remarks: ______________________

____

____

____

Location map: Show line sizes and distance to next cross connected line. Show valves and hydrant branch size. Indicate north. Show flowing hydrants – Label A_1, A_2 A_3, A_4. Show location of static and residual – Label B.

Indicate B Hydrant ____ Sprinkler ____ Other (identify) ______________________

Figure 2-11 Sample hydrant flow test report.

Chapter 3 Marking of Hydrants

3-1 Classification of Hydrants. Hydrants should be classified in accordance with their rated capacities (at 20 psi [1.4 bar] residual pressure or other designated value) as follows:

Class AA — Rated capacity of 1,500 gpm or greater (5,680 L/min)

Class A — Rated capacity of 1,000-1,499 gpm (3,785-5,675 L/min)

Class B — Rated capacity of 500-999 gpm (1,900-3,780 L/min)

Class C — Rated capacity of less than 500 gpm (1,900 L/min)

3-2 Marking of Hydrants.

3-2.1 Public Hydrants. All barrels are to be chrome yellow except in cases where another color has already been adopted. The tops and nozzle caps should be painted with the following capacity-indicating color scheme to provide simplicity and consistency with colors used in signal work for safety, danger, and intermediate condition:

Class AA — Light blue
Class A — Green
Class B — Orange
Class C — Red

For rapid identification at night, it is recommended that the capacity colors be of a reflective-type paint.

Hydrants rated at less than 20 psi (1.4 bar) should have the rated pressure stenciled in black on the hydrant top.

In addition to the painted top and nozzle caps, it may be advantageous to stencil the rated capacity of high volume hydrants on the top.

The classification and marking of hydrants provided for in this chapter anticipate determination based on individual flow test. Where a group of hydrants can be used at the time of a fire, some special marking designating group-flow capacity may be desirable.

3-2.2 Flush Hydrants. Location markers for flush hydrants should carry the same color background as stated above for class indication, with such other data stenciled thereon as deemed necessary.

3-2.3 Private Hydrants. Marking on private hydrants within private enclosures is to be at the owner's discretion. When private hydrants are located on public streets, they should be painted red, or some other color, to distinguish them from public hydrants.

Index

JOHNSON CONTROLS

Johnson Controls, Inc
Box 105123
Fort Irwin, California 92310-5123

Fort Irwin Installation Support Project

Date: 1/23/97

Number of pages including cover sheet: ____

To:

Blair Horst

Keller & Gannon

DATE REC'D: 1/23/97

TIME REC'D: 9:03

PROJECT No.:

ORIGINAL: BIH /FILE

Fax phone: 415-864-3681 — MR

COPY:

Phone: 415-621-1199

From:	John R. Spangler
Phone:	(619) 380-5738
Fax phone:	(619) 380-4595

Message: Good morning Blair; hope it's not too wet there. Here are the Reverse Osmosis flush points you requested. Also, the distribution flush points in case you need those as well. If you have any questions, please give Ken Alef or myself a call. Stay dry!

John R. Spangler

FIRMS SUMMARY OF HYDRANTS
FORT IRWIN FIRE DEPARTMENT
309 Hydrants

January 23, 1997

Hydrant number	Location	(Avialble water) DATE.	GPM at	PSI	Thread type	Class color	Aux pump	Out of service	Date out
0001	INNER LP/LANGFORD	5/26/93	811	20	S	GREEN	NO	NO	
0013	BEHIND BLDG. 13	5/26/93	406	20	S	RED	NO	NO	
0014	13 BARSTOW RD	5/26/93	1230	20	S	RED	NO	NO	
0021	BLDG. 21 PARK LOT	5/26/93	499	20	S	ORANGE	NO	NO	
0023	SCHOOL BASKETBALL CT	5/19/93	522	20	S	GREEN	NO	NO	
0028	LITTLE BIGHORN SP 28		0	0	S	RED	NO	NO	
0034	34 GOLDSTONE	5/26/93	1099	20	S	GREEN	NO	NO	
0035	LITTLE BIG HORN	5/19/93	816	20	S	RED	NO	NO	
0037A	37 INNERLOOP	5/19/93	1542	20	S	GREEN	NO	NO	
0037B	37 GOLDSTONE	5/19/93	1973	20	S	RED	NO	NO	
0042	LITTLE BIG HORN	5/19/93	859	20	S	GREEN	NO	NO	
0043	R/O PLANT GOLDSTONE		0	0	S	GREEN	NO	YES	
0053	SP. 53 GRENADA WAY		0	0	S	ORANGE	NO	NO	
0059	SP. 59 GRENADA WAY		0	0	S	ORANGE	NO	NO	
0068	SP. 68 GRENADA WAY		0	0	S	ORANGE	NO	NO	
0073	SP. 73 GRENADA WAY		0	0	S	ORANGE	NO	NO	
0080	SP. 80 GRANADA WAY		0	0	S	ORANGE	NO	NO	
0085	85 GRENADA COURT		0	0	S	RED	NO	NO	
0098	GOLDSTONE C AVE	5/26/93	805	20	S	GREEN	NO	YES	8/16/95
0099	LANGFORD & BARSTOW		0	0	S	GREEN	NO	NO	
0106	INNERLOOP & 1ST		0	0	S	RED	NO	NO	
0110	1ST B AVE	5/26/93	551	20	S	GREEN	NO	NO	
0115	INNERLOOP	5/26/93	754	20	S	RED	NO	NO	
0121	2ND		0	0	S	RED	NO	NO	
0123B	AVE B 2ND	5/26/93	632	20	S	RED	NO	NO	
0130	3RD B	5/26/93	918	20	S	RED	NO	NO	
0152	4TH B		0	0	S	RED	NO	NO	
0156	156 B		0	0	S	GREEN	NO	NO	
0166A	HOSPITAL	5/26/93	1285	20	S	RED	NO	NO	
0166B	HOSPITAL	5/26/93	1507	20	S	RED	NO	NO	
0171	BLDG. 171 DENTAL CLN	5/26/93	765	20	S	RED	NO	NO	
0182	5TH & AVE B		0	0	S	GREEN	NO	NO	
0199	PORKCHOP BALL FIELD	5/10/93	1066	20	S	GREEN	NO	YES	5/21/94
0202	B AVE SOLIDERS CLUB	5/26/93	738	20	S	RED	NO	NO	
0226	226 C AVE	5/26/93	1015	20	S	GREEN	NO	NO	
0230	AVEC 230	5/26/93	1035	20	S	GREEN	NO	NO	
0242	AVE. C & 3RD ST.	5/28/93	1231	20	S	GREEN	NO	NO	
0248	248 BARSTOW RD	5/26/93	1159	20	S	RED	NO	NO	
0249A	249 NORTH		0	0	S	RED	NO	NO	
0249B	IN FRONT BLDG. 249		0	0	S	GREEN	NO	NO	
0250	BARSTOW RD./BLDG 250		0	0	S	RED	NO	NO	
0251A	SE CORNER BLDG. 251		0	0	S	ORANGE	NO	NO	
0251B	S. CORNER BLDG. 251	5/28/93	1245	20	S	GREEN	NO	NO	
0251C	BARSTOW & BLDG. 251	5/26/93	1148	20	S	GREEN	NO	NO	
0252	AVE C BLDG. 252	5/28/93	1460	20	S	GREEN	NO	NO	
0255	BETWEEN 255 & 256		0	0	S	GREEN	NO	NO	
0256	BLDG. 256 & B AVE.		0	0	S	GREEN	NO	NO	
0257A	5TH & BLDG. 257		0	0	S	GREEN	NO	NO	
0257B	257 SIDEWALK BARSTOW		0	0	S	RED	NO	NO	

Hydrant number	Location	(Avialble water) DATE,	GPM at	PSI	Thread type	Class color	Aux pump	Out of service	Date out
0261	PARKING LOT 261	5/28/93	1739	20	S	GREEN	NO	NO	
0265	PARKING LOT 265	5/28/93	1623	20	S	GREEN	NO	NO	
0273	273 1ST C AVE	5/26/93	803	20	S	GREEN	NO	NO	
0279	BARSTOW 1ST	5/26/93	1099	20	S	GREEN	NO	NO	
0281	281 BARSTOW RD	5/26/93	1247	20	S	GREEN	NO	NO	
0306	CONSTITUTION PARK				S	GREEN	NO	NO	
0318	2ND & D ST.		0	0	S	ORANGE	NO	NO	
0322	2ND & BLDG. 322		0	0	S	GREEN	NO	NO	
0333	AVE. E & BLDG. 333		0	0	S	GREEN	NO	NO	
0344	3RD & AVE. E		0	0	S	GREEN	NO	NO	
0347	BARSTOW 3RD		0	0	S	GREEN	NO	NO	
0361	BEHIND REC CENTER	5/26/93	1507	20	S	RED	NO	NO	
0362	3RD & BLDG. 362		0	0	S	RED	NO	YES	8/09/95
0364	4TH & AVE. E		0	0	S	GREEN	NO	NO	
0385	5TH AND BARSTOW RD.		0	0	S	GREEN	NO	NO	
0408	LANGFORD & G AVE.		0	0	S	GREEN	NO	NO	
0411	F AVE. & 1ST		0	0	S	GREEN	NO	NO	
0415	1ST & BLDG. 415		0	0	S	GREEN	NO	YES	8/10/95
0421	1ST & BLDG. 421		0	0	S	GREEN	NO	NO	
0426	G AVE. & BLDG. 426		0	0	S	GREEN	NO	NO	
0427	2ND & F AVE.		0	0	S	GREEN	NO	NO	
0439	2ND & BLDG. 439		0	0	S	GREEN	NO	NO	
044444			0	0	S	GREEN	NO	NO	
044445			0	0	S	GREEN	NO	NO	
0450	2ND & BLDG. 450		0	0	S	GREEN	NO	NO	
0464	3RD & BLDG. 464	5/26/93	637	20	S	RED	NO	NO	
0474	3RD & BLDG. 474		0	0	S	RED	NO	NO	
0478	AVE. G & BLDG. 478		0	0	S	GREEN	NO	NO	
0485	4TH & AVE. F		0	0	S	GREEN	NO	NO	
0487	4TH & BLDG. 487		0	0	S	GREEN	NO	NO	
0491	4TH & BLDG. 491		0	0	S	GREEN	NO	NO	
0493	4TH & G AVE.		0	0	S	GREEN	NO	NO	
0505	SOUTHLOOP & LANGFORD		0	0	S	GREEN	NO	NO	
0517	1ST & BLDG. 517		0	0	S	GREEN	NO	NO	
0521	1ST & BLDG. 521		0	0	S	GREEN	NO	NO	
0523	1ST & SOUTHLOOP		0	0	S	GREEN	NO	NO	
0531	2ND & BLDG. 531		0	0	S	GREEN	NO	NO	
0538	SOUTHLOOP BLDG. 538		0	0	S	GREEN	NO	NO	
0543	2ND & BLDG. 543		0	0	S	GREEN	NO	NO	
0558	3RD & BLDG. 558		0	0	S	GREEN	NO	NO	
0568	3RD & BLDG.568		0	0	S	GREEN	NO	NO	
0578	SOUTHLOOP & BLDG 578		0	0	S	GREEN	NO	NO	
0588	SOUTH LOOP & 5TH		0	0	S	GREEN	NO	NO	
0605A	YARD BEHIND 605		0	0	S	GREEN	NO	NO	
0608	5TH & BLDG. 608		0	0	S	GREEN	NO	NO	
0614	5TH & BLDG. 614		0	0	S	GREEN	NO	NO	
0621	5TH & BLDG. 621		0	0	S	GREEN	NO	NO	
0623	5TH & BLDG. 623		0	0	S	GREEN	NO	NO	
0639	5TH $ G BLDG. 493		0	0	S	GREEN	NO	NO	
0646	5TH & BLDG. 646		0	0	S	GREEN	NO	NO	
0680A	FRONT OF BLDG. 680		0	0	S	GREEN	NO	NO	
0680B	W. SIDE BLDG. 680	5/28/93	868	20	S	GREEN	NO	NO	
0680C	E. SIDE BLDG. 680	5/28/93	583	20	S	GREEN	NO	NO	
0680D	N. SIDE BLDG. 680	5/28/93	975	20	S	GREEN	NO	NO	
0681A	FRONT GATE BLDG. 681	5/28/93	575	20	S	ORANGE	NO	NO	
		5/28/93	664	20	S	GREEN	NO	NO	

Hydrant number	Location	(Avialble water) DATE,	GPM at	PSI	Thread type	Class color	Aux pump	Out of service	Date out
0681B	E. SIDE BLDG. 681	5/28/93	809	20	S	GREEN	NO	NO	
0681C	N. SIDE BLDG. 681	5/28/93	979	20	S	GREEN	NO	NO	
0681D	W. SIDE BLDG. 681	5/28/93	818	20	S	GREEN	NO	NO	
0683	7TH ST. PUMP STA.		0	0	S	LT BLUE	NO	NO	
0708	5TH & CHLORINE PLANT		0	0	S	RED	NO	YES	6/10/94
0826	BLDG. 826 & 5TH ST.		0	0	S	RED	NO	NO	
0828	BLDG. 828		0	0	S	RED	NO	NO	
0830	BLDG. 830 BACK LOT		0	0	S	GREEN	NO	NO	
0840	LANGFORD & MATES		0	0	S	GREEN	NO	NO	
0841	LANGFORD & BLDG. 830		0	0	S	GREEN	NO	NO	
0850	BLDG. 850		0	0	S	GREEN	NO	NO	
0855	BLDG. 855 & DEPOT RD		0	0	S	ORANGE	NO	NO	
0857	BLDG. 857		0	0	S	GREEN	NO	NO	
0859	DEPOT RD		0	0	S	GREEN	NO	NO	
0860	BEHIND BLDG 860		0	0	S	GREEN	NO	NO	
0862	BLDG. 862 & DEPOT RD		0	0	S	GREEN	NO	NO	
0873	BLDG 873		0	0	S	GREEN	NO	NO	
0873A	BLDG 873		0	0	S	GREEN	NO	NO	
0873B	BLDG 873		0	0	S	GREEN	NO	NO	
0873C	BLDG 879		0	0	S	GREEN	NO	NO	
0879A	BLDG 879		0	0	S	GREEN	NO	NO	
0879B	BLDG. 879		0	0	S	GREEN	NO	NO	
0879C	BLDG 879		0	0	S	GREEN	NO	NO	
0879D	BLDG 879		0	0	S	GREEN	NO	NO	
0905	BLDG. 905	5/26/93	855	20	S	RED	NO	NO	
0910	LANGFORD & BLDG. 910		0	0	S	ORANGE	NO	NO	
0918A	LANGFORD & BLDG. 918		0	0	S	GREEN	NO	NO	
0918B	BLDG. 918		0	0	S	RED	NO	NO	
0920A	LANGFORD & BLDG. 920		0	0	S	GREEN	NO	NO	
0920B	COMMOSARY COMPLEX		0	0	S	RED	NO	NO	
0920C	LANGFORD & BLDG. 920		0	0	S	GREEN	NO	NO	
0920D	COMMISARY COMPLEX		0	0	S	RED	NO	NO	
0930	G & BLDG. 930		0	0	S	GREEN	NO	NO	
0934A	FRONT OF BLDG. 934		0	0	S	ORANGE	NO	NO	
0934B	REAR YARD BLDG. 934		0	0	S	RED	NO	NO	
0934C	G & INNERLOOP		0	0	S	ORANGE	NO	NO	
0941	LANGFORD & BLDG. 941		0	0	S	GREEN	NO	NO	
0976A	REAR OF BLDG. 976		0	0	S	RED	NO	NO	
0976B	BLDG. 976		0	0	S	GREEN	NO	NO	
0983	INNERLOOP & 983		0	0	S	ORANGE	NO	NO	
0985	INNERLOOP & 985		0	0	S	ORANGE	NO	NO	
0988	BLDG. 988 & INNER LP		0	0	S	RED	NO	NO	
1202	1202 NORMANDY	5/10/93	1110	20	S	GREEN	NO	NO	
1210	SALERNO/NORMANDY	5/10/93	1211	20	S	GREEN	NO	NO	
1313	1313 NORMANDY	5/10/93	1189	20	S	GREEN	NO	NO	
1318	1318 MEUSE ARGONNE	5/19/93	1102	20	S	GREEN	NO	NO	
1319	INNERLOOP GOLDSTONE	5/19/93	1808	20	S	GREEN	NO	NO	
1322A	1322	5/19/93	996	20	S	GREEN	NO	NO	
1322B	GOLDSTONE E OF 1322	5/19/93	2381	20	S	GREEN	NO	NO	
1323	GOLDSTONE W OF 1322	5/19/93	1102	20	S	GREEN	NO	NO	
1716	1716 PORKCHOP HILL O	5/10/93	868	20	S	GREEN	NO	NO	
1720	1720 PORKCHOP HILL		0	0	S	RED	NO	NO	
1824	NORMANDY PORKCHOP HL	5/10/93	1065	20	S	GREEN	NO	NO	
1826	1826 NORMANDY	5/10/93	964	20	S	GREEN	NO	NO	
1844	1844 NORMANDY		0	0	S	RED	NO	NO	

Hydrant number	Location	(Avialble water) DATE,	GPM at	PSI	Thread type	Class color	Aux pump	Out of service	Date out
1904	1904 ANZIO		0	0	S	GREEN	NO	NO	
199	PORK CHOP TRAINING A		0	0	S	RED	NO	NO	
2000	SALERNO/BASTOGNE	5/08/93	531	20	S	GREEN	NO	NO	
2008	2008 SALERNO	5/08/93	541	20	S	GREEN	NO	NO	
2012	SALERNO/ANZIO		0	0	S	GREEN	NO	NO	
2107	2107 SHILOH	5/08/93	330	20	S	GREEN	NO	NO	
2300	ANTIETAM/BASTOGNE	5/08/93	435	20	S	GREEN	NO	NO	
2307	2307 ANTIETAM	5/08/93	466	20	S	GREEN	NO	NO	
2407	2407 ANZIO	5/08/93	357	20	S	GREEN	NO	NO	
2415	2415 ANZIO	5/08/93	453	20	S	GREEN	NO	NO	
2507	2507 MONTEREY	5/08/93	475	20	S	GREEN	NO	NO	
2601	2601 ST. MIHIEL		0	0	S	ORANGE	NO	YES	3/22/94
2611	2611 ST. MIHIEL		0	0	S	ORANGE	NO	YES	3/22/94
2619	2619 ST. MIHIEL		0	0	S	RED	NO	NO	
2703	2703 BATAAN LOOP		0	0	S	ORANGE	NO	NO	
2805	2805 YORKTOWN		0	0	S	ORANGE	NO	NO	
2815	2815 YORKTOWN		0	0	S	ORANGE	NO	NO	
2910	2910 BATAAN LOOP		0	0	S	ORANGE	NO	NO	
3005	3005B RHINELAND		0	0	S	RED	NO	NO	
3009	3009A RHINELAND		0	0	S	RED	NO	NO	
3015	3015A RHINELAND		0	0	S	RED	NO	NO	
3105	3105B RHINELAND		0	0	S	RED	NO	NO	
3306	3306A OMAHA		0	0	S	GREEN	NO	NO	
3309	3309A OMAHA		0	0	S	RED	NO	NO	
3314	3314B OMAHA		0	0	S	RED	NO	NO	
3320	3320D OMAHA		0	0	S	RED	NO	NO	
3322	3322D GOLDSTONE		0	0	S	RED	NO	NO	
3328	3328A GOLDSTONE		0	0	S	RED	NO	NO	
3401	3401B TIPPECANOE		0	0	S	ORANGE	NO	NO	
3405	3405B TIPPECANOE		0	0	S	ORANGE	NO	NO	
3408	3408B TIPPECANOE		0	0	S	ORANGE	NO	NO	
3415	3415B TIPPECANOE		0	0	S	ORANGE	NO	NO	
3501	3501B WILDERNESS		0	0	S	ORANGE	NO	NO	
3503	3503A WILDERNESS		0	0	S	ORANGE	NO	NO	
3507	3507A WILDERNESS		0	0	S	ORANGE	NO	NO	
3513	3513B WILDERNESS		0	0	S	ORANGE	NO	NO	
3517	3517A WILDERNESS		0	0	S	ORANGE	NO	NO	
3521	3521 MEUSE ARGONNE		0	0	S	ORANGE	NO	NO	
3601	3601B RHINELAND		0	0	S	RED	NO	NO	
3605	3605A RHINELAND		0	0	S	RED	NO	NO	
3611	3611A RHINELAND		0	0	S	RED	NO	NO	
3617	3617A RHINELAND		0	0	S	GREEN	NO	NO	
3623	3623A RHINELAND		0	0	S	ORANGE	NO	NO	
3629	3629A RHINELAND		0	0	S	GREEN	NO	NO	
3632	3632D GOLDSTONE		0	0	S	RED	NO	NO	
3635	3635D GOLDSTONE		0	0	S	RED	NO	NO	
3681	3681 PLEIKU		0	0	S	ORANGE	NO	NO	
3689	3689 PLEIKU		0	0	S	ORANGE	NO	NO	
3691	3691 SANTIAGO		0	0	S	ORANGE	NO	NO	
3695	3695 SANTIAGO		0	0	S	ORANGE	NO	NO	
3700	3700 MONMOUTH		0	0	S	ORANGE	NO	NO	
3704	3704 MONMOUTH		0	0	S	ORANGE	NO	NO	
3712	3712 CAMBRIA		0	0	S	ORANGE	NO	NO	
3718	3718 CAMBRIA		0	0	S	ORANGE	NO	NO	
3720	3720 SICILY		0	0	S	ORANGE	NO	NO	

Hydrant number	Location	(Avialble water) DATE.	GPM at	PSI	Thread type	Class color	Aux pump	Out of service	Date out
3722	3722 SICILY		0	0	S	ORANGE	NO	NO	
3725	3725 ARDENNES		0	0	S	ORANGE	NO	NO	
3730	3730 APPAMATOX		0	0	S	ORANGE	NO	NO	
3737	3737 APPAMATOX	4/12/95	919	50	S	ORANGE	NO	NO	
3739	3739 GETTYSBURG		0	0	S	GREEN	NO	NO	
3744	3744 GETTYSBURG		0	0	S	ORANGE	NO	NO	
3746	3746 FREDRICKSBURG		0	0	S	GREEN	NO	NO	
3750	3750 FREDRICKSBURG		0	0	S	ORANGE	NO	NO	
3803	3803 CORREGIDOR		0	0	S	ORANGE	NO	NO	
3814	3814 SUMPTER		0	0	S	ORANGE	NO	NO	
3824	3824 BUENA VISTA		0	0	S	ORANGE	NO	YES	4/12/95
3832	3832 SARATOGA		0	0	S	GREEN	NO	NO	
3843	3843 VERA CRUZ		0	0	S	ORANGE	NO	NO	
3854	3854 VALLEY FORGE		0	0	S	ORANGE	NO	YES	4/12/95
3863	3863 RED PASS		0	0	S	BLACK	NO	NO	
3868	3868 MOJAVE LANE		0	0	S	ORANGE	NO	NO	
3869	3869 RED PASS		0	0	S	ORANGE	NO	NO	
3880	3880 GRANITE PASS		0	0	S	ORANGE	NO	NO	
3883	3883 COYOTE COVE		0	0	S	ORANGE	NO	NO	
3898	3898 GRANITE PASS		0	0	S	ORANGE	NO	NO	
3901	3901 CMDER LOOP		0	0	S	GREEN	NO	NO	
3911	3911 TIEFORT		0	0	S	GREEN	NO	NO	
3918	3918 TEIFORT		0	0	S	GREEN	NO	NO	
3926	3926 IRWIN DR		0	0	S	RED	NO	NO	
3935	3935 BITTER SPRS		0	0	S	GREEN	NO	NO	
3945	3945 BITTER SPRS		0	0	S	GREEN	NO	NO	
3951	3951 AVAWATZ		0	0	S	GREEN	NO	NO	
3957	3957 DRINKWATER		0	0	S	GREEN	NO	NO	
3968	3968 DRINKWATER		0	0	S	GREEN	NO	NO	
3977	3977 ALVORD		0	0	S	GREEN	NO	NO	
3982	3982 LEACH LAKE		0	0	S	GREEN	NO	NO	
3992	3992 LEACH LAKE		0	0	S	GREEN	NO	NO	
4009	4009 HIDDEN SPRS		0	0	S	GREEN	NO	NO	
4017	4017 HIDDEN SPRS		0	0	S	GREEN	NO	NO	
4035	4035 ALVORD		0	0	S	GREEN	NO	NO	
4049	4049A SODA MTN. DR.		0	0	S	RED	NO	NO	
4054	4054A DAISY MINE RD.		0	0	S	RED	NO	NO	
4064	4064A DAISY MINE		0	0	S	RED	NO	NO	
4071	4071A OWLS HEAD		0	0	S	GREEN	NO	NO	
4081	4081B OWLS HEAD		0	0	S	GREEN	NO	NO	
4090	4090 DENNING SPRINGS		0	0	S	RED	NO	NO	
4099	4099B DENNING SPRNGS		0	0	S	RED	NO	NO	
4100A	4100 GOLDSTONE EAST		0	0	S	RED	NO	NO	
4100B	4100 GOLDSTONE WEST		0	0	S	RED	NO	NO	
5015	5015C MOUNTAIN LANE		0	0	S	RED	NO	NO	
5023	5023B MOUNTAIN LANE		0	0	S	RED	NO	NO	
5034	5034B CALICO		0	0	S	RED	NO	NO	
5048	5048A SPANISH CYN		0	0	S	GREEN	NO	NO	
5052	5052A SPANISH CYN		0	0	S	GREEN	NO	NO	
5059	5059A GARLIC SPRS		0	0	S	GREEN	NO	NO	
5062	5062A GARLIC SPRS		0	0	S	GREEN	NO	NO	
5071	5071A CAVE SPRS		0	0	S	GREEN	NO	NO	
5083	5083B RAINBOW BASIN		0	0	S	GREEN	NO	NO	
5087	5087B SUPERIOR VALLY		0	0	S	GREEN	NO	NO	
5094	5094A SUPERIOR VALLY		0	0	S	GREEN	NO	NO	

Hydrant number	Location	(Avialble water DATE.	GPM at	PSI)	Thread type	Class color	Aux pump	Out of service	Date out
5101	5101B SWEETWATER SPG		0	0	S	GREEN	NO	NO	
5107	5107B SWEETWATER SPG		0	0	S	GREEN	NO	NO	
5116	5116A BLUE BELL CT.		0	0	S	GREEN	NO	NO	
5121	5121B BLUE BELL CT.		0	0	S	GREEN	NO	NO	
5129	5129C RIO HONDO CV.		0	0	S	RED	NO	NO	
5132	5132A SILURIAN HILLS		0	0	S	RED	NO	NO	
5136	5136B SULARIAN HILLS		0	0	S	GREEN	NO	NO	
5143	5143D AFTON CANYON		0	0	S	GREEN	NO	NO	
5150	5150 CRACKERJACK LN.		0	0	S	RED	NO	NO	
5154	5154 CRACKERJACK LN.		0	0	S	RED	NO	NO	
5168	5168 PARADISE MT. LP		0	0	S	RED	NO	NO	
5178	5178 CRACKERJACK LN.		0	0	S	RED	NO	NO	
5181	5181 CRACKERJACK LN.		0	0	S	RED	NO	NO	
5189	5189 DESERT KING DR.		0	0	S	RED	NO	NO	
5193	5193 DESERT KING DR.		0	0	S	RED	NO	NO	
5201	5201 GOLD NUGGET DR.		0	0	S	RED	NO	NO	
5210	5210 GOLD NUGGET DR.		0	0	S	RED	NO	NO	
5216	5216 IRON MTN. CT.		0	0	S	RED	NO	NO	
5220	5220 SILVERMINE WY.		0	0	S	RED	NO	NO	
5224	5224 PROSPECT CT.		0	0	S	RED	NO	NO	
5226	5226 SILVERMINE WY.		0	0	S	RED	NO	NO	
5252A	5252A CHUCKAWALLA		0	0	S	RED	NO	NO	
5266A	5266A BIG HORN LN.		0	0	S	RED	NO	NO	
5269A	5269A BIG HORN LN.		0	0	S	RED	NO	NO	
5275B	5275B TORTOIS		0	0	S	RED	NO	NO	
6015	BLDG. 6015 DUST BOWL		0	0	S	RED	NO	NO	
6030	BLDG. 6030 DUST BOWL		0	0	S	RED	NO	NO	
6045	BLDG. 6045 DUST BOWL		0	0	S	RED	NO	NO	
6061	BLDG. 6061 DUST BOWL		0	0	S	RED	NO	NO	
7600A	ASD SOUTH END		0	0	S	RED	NO	NO	
7601B	ASD		0	0	S	GREEN	NO	NO	
7602A	BLDG 7602		0	0	S	RED	NO	NO	
7602B	BLDG 7602		0	0	S	RED	NO	NO	
7632	BLDG. 7632		0	0	S	GREEN	NO	NO	
7701A	BULK POL		0	0	S	RED	NO	NO	
7701B	BULK POL		0	0	S	GREEN	NO	NO	
7702A	ASD RD		0	0	S	GREEN	NO	NO	
7702B	ASD RD		0	0	S	GREEN	NO	NO	
7720A	ASD RD.		0	0	S	RED	NO	NO	
7720B	ASD. RD.		0	0	S	RED	NO	NO	

This project is a reevaluation of an energy resource opportunity (ERO) previously addressed in the Fort Irwin Integrated Resource Assessment prepared by the Pacific Northwest Laboratory (operated by Battelle Memorial Institute) and submitted February 1997.

Introduction

The well pumps at Fort Irwin currently operate intermittently throughout the day to maintain adequate capacity in the one million gallon underground water storage tank and the three million gallon surface water storage tanks. Adding another storage tank and revising well pumping schedules to avoid the most costly on-peak period will lower both electricity usage and demand charges. Although overall electricity usage will not be decreased by shifting well pump operations to mid-peak and off-peak periods, the overall cost of energy for water pumping will be reduced since it will be consumed during lower-cost rate periods.

Technical Assumptions

1. Currently, there are 11 operating wells at Fort Irwin, of which one is dedicated to the Airfield and , thus, cannot be included in the load shifting savings. Total pumping during FY96 exceeded 1,057 million gallons, with peak summer month average consumption of 4.6 million gallons per day (mgd) and minimum winter month average consumption of 2.0 mgd.

2. Energy consumption for each SCE rate period was estimated as the product of total annual well kWh energy consumption and the fraction of total annual energy consumption for Fort Irwin consumed during that rate period based on SCE billings. Total annual energy consumed by the well pumps was calculated as the sum of the products of annual operating hours and measured input kWs to the well pump motors.

3. All well water pumping that now occurs between 1200 and 1800 hours is assumed to be shifted to the period between 2300 and 0800 the following morning. This shift will move all well pump summer consumption and demand from summer on-peak to summer off-peak periods and a portion of well pump winter consumption from winter mid-peak to winter off-peak periods. The consumption shifted is estimated as the fraction of mid-peak hours shifted to total daily mid-peak hours, or 6/13.

4. All of the well pumps are operating during some portion of the summer on-peak period; therefore, shifting operation to summer off-peak periods will reduce the summer on-peak demand charge for well pumping to zero. The reduction in demand charges during the 8 winter months is also estimated as the fraction of mid-peak hours shifted to total daily mid-peak hours, or 6/13, with the kW shifted valued at the monthly maximum demand rate of $6.60 per kW.

5. A new water tank sized at 750,000 gallons will provide enough storage to eliminate well pump operations during the summer on-peak period from 1200 to 1800 hours. Proposed location of the new tank is adjacent to the Ammunition Storage Area, which will allow gravity feed to the Administration and Industrial Areas located at lower elevations.

6. The following table summarizes well pump operating data. Well pump power values were computed

from data collected during the field investigation or from data appearing on previous pump efficiency test reports. Pump operating hour data were provided by the Fort Irwin DEH Water Department.

Pump Designation	Input kW	Annual Operating Hours	Total Annual kWh Usage
B-1	69.1	3,349.8	231,471
B-4	57.1	2,976.2	169,941
B-5	82.9	5,927.3	491,375
B-6	72.3	4.2	304
L-1	79.8	3,115.5	248,617
L-2	70.5	1,997.0	140,789
L-3	83.7	965.7	80,829
I-3	68.1	3,114.0	212,063
I-5	65.2	3,769.8	245,791
I-7	138.1	1,963.6	271,173
	786.8		2,092,353

COMPUTATION SHEET

Keller & Gannon
Engineers Architects
Since 1941

Computed By:	RCL	**DOMESTIC WATER SYSTEM:**	**Project:**	Fort Irwin - Water Conservation
Checked By:	BIH	**ADDITIONAL WATER STORAGE**		
Date:	Feb '97	**&**	**Project No.**	16-403-21
Revision:	April '97	**WELL PUMP LOAD SHIFTING**	**Sheet No.**	3 of 6

Electrical Consumption, Demand and Cost Savings

The following tables develop existing energy usage, demand and cost for the domestic system well pumps and projected future energy usage, demand and cost after the proposed load shifting:

Existing Consumption:			Existing Cost:	
Summer On-Peak =	194,589	kWh	$	18,334
Summer Mid-Peak =	267,821	kWh	$	15,659
Summer Off-Peak =	472,872	kWh	$	17,771
Winter Mid-Peak =	508,442	kWh	$	35,952
Winter Off-Peak =	648,629	kWh	$	25,128
	2,092,353	kWh	$	112,844

Existing Demand:			Existing Cost:	
Summer On-Peak =	787	kW	$	77,283
Summer Mid-Peak =	787	kW	$	8,500
Winter Mid-Peak =	787	kW	$	41,554
			$	127,337

Consumption After Load Shifting:			Future Cost:	
Summer On-Peak =	-	kWh	$	-
Summer Mid-Peak =	267,821	kWh	$	15,659
Summer Off-Peak =	667,461	kWh	$	25,083
Winter Mid-Peak =	273,776	kWh	$	19,359
Winter Off-Peak =	883,295	kWh	$	34,219
	2,092,353		$	94,320

Demand After Load Shifting:			Future Cost:	
Summer On-Peak =	-	kW	$	-
Summer Mid-Peak =	787	kW	$	8,500
Winter Mid-Peak =	424	kW	$	22,375
			$	30,875

Total Consumption Savings	$	18,524
Total Demand Savings	$	96,462
Overall Cost Savings	$	114,986

Additional Operations and Maintenance Costs

The new storage tank installation will require additional maintenance manhours to inspect and maintain the tank and associated piping and valves. Additional annual O&M costs are estimated as follows:

2 manhours/month x 12mos/year x $26.00/hour =	$	624
Misc. materials	$	100
Total Annual Additional O&M Costs	$	724

CONSTRUCTION COST ESTIMATE	Date Prepared: Feb-97 (Rev. April-97)	Sheet: 4 of 6
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: ADDITIONAL WATER STORAGE TANK	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Investigation & Demolition									
Survey, Pipeline	6,400	LF	$0.03	$192	$0.54	$3,456	$0	$0	$3,648
Drawing, Boring Details	1	EA	$0	$0	$170.00	$170	$0	$0	$170
Auger Holes, 4-Ft Deep, every 100 LF	64	EA	$0	$0	$25.00	$1,600	$31.40	$2,010	$3,610
Field Stake-out, Elevations	1.00	EA	$0	$0	$390	$390	$0	$0	$390
Drawing showing Boring Details	1.00	EA	$0	$0	$170	$170	$0	$0	$170
Report & Recommendations from Engineer	1.00	EA	$0	$0	$375	$375	$0	$0	$375
Mobilization/Demobilization, minimum	1.00	EA	$0	$0	$123	$123	$154	$154	$277
Clearing - Hand	0.11	Acre	$0	$0	$1,350	$152	$505	$57	$209
Subtotal, Site Investigation & Demolition				**$0**		**$1,058**		**$154**	**$8,848**
Excavation / Backfill / Compaction (3-inch deep, 70-Ft x 70-Ft Area, 6% Grade)									
Excavate/Backfill by Hand	426	CY	$0	$0	$11.55	$4,920	$0	$0	$4,920
Compaction by Roller, Walking	426	CY	$0	$0	$2.95	$1,257	$0.86	$366	$1,623
Subtotal, Excavation / Backfill / Compaction				**$0**		**$6,177**		**$366**	**$6,543**
StorageTank Pad (Concrete)									
Forms in Place, Equip Foundation, 1 Use	157	SFCA	$2.27	$357	$7.60	$1,194	$0.26	$41	$1,591
Reinforcing Steel, in place	2.623	Ton	$510.00	$1,338	$395.00	$1,036	$0.00	$0	$2,374
Concrete In Place, nic Forms	145.4	CY	$63.50	$9,236	$21.50	$3,127	$0.37	$54	$12,417
Anchor Bolts, 3/4-inch Dia x 8-inch long	315	EA	$4.60	$1,449	$0.44	$139	$0.39	$123	$1,710
Subtotal, Tank Pad (Concrete)				**$12,379**		**$5,496**		**$218**	**$18,092**
Storage Tank and Appurtenances									
Storage Tank, 750,000 Gals, Steel, Ground Level	1	EA	$161,250	$161,250	$43,000	$43,000	$10,750	$10,750	$215,000
Impressed Current Cathodic Protection System, Solar Powered	1	EA	$12,000	$12,000	$3,000	$3,000	$0	$0	$15,000
Subtotal, Storage Tank and Appurtenances				**$161,250**		**$43,000**		**$10,750**	**$230,000**
Piping, Valves and Fittings									
Ductile Iron, Cement Lined, 12" Diameter	6,400	LF	$18.90	$120,960	$9.20	$58,880	$1.51	$9,664	$189,504
Corrosion Resistance Wrap & Coat	6,400	LF	$3.05	$19,520	$0	$0	$0	$0	$19,520
Ductile Iron Fittings, 12" Diameter	4	EA	$345.00	$1,380	$37.00	$148	$6.05	$24	$1,552
Butterfly Valves with Boxes, Cast Iron, 12" Diameter	2	EA	$1,250	$2,500	$221.00	$442	$36.00	$72	$3,014
Trenching, 40 HP, Riding, 16"Wx36"D	6,400	LF	$0	$0	$0.29	$1,856	$0.30	$0	$1,856
Backfill Trench, 1 CY Bucket Min. Haul	1,540	CY	$0	$0	$0.74	$1,140	$0.58	$0	$1,140
Pipe Bedding, Side Slope 1/2:1	6,400	LF	$1.01	$6,464	$1.39	$8,896	$2.40	$2	$15,362
Compaction by Vibr. Plate	6,400	LF	$0	$0	$0.37	$2,368	$0.29	$0	$2,368
Subtotal, Piping, Valves and Fittings				**$150,824**		**$71,362**		**$9,763**	**$231,948**
Telemetry System									
Tank Water Level Sensor	1	EA	$2,500	$2,500	$500.00	$500	$0	$0	$3,000
Telemetry Transmitter	1	EA	$3,000	$3,000	$800.00	$800	$0	$0	$3,800
Solar Module and Battery	1	EA	$800	$800	$300.00	$300	$0	$0	$1,100
Subtotal, Electrical Controls and Wiring				**$6,300**		**$1,600**		**$0**	**$7,900**
Subtotal				$330,753		$134,065		$22,284	$504,516

CONSTRUCTION COST ESTIMATE	Date Prepared: Feb-97 (Rev. April-97)	Sheet: 5 of 6
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **ADDITIONAL WATER STORAGE TANK**	Estimator: **BIH**	Checked By: **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
California Sales Tax	7.75%	%		$25,633				$1,727	$27,360
Subtotal									$531,877
Contractor OH & Profit	25.0%	%							$132,969
Subtotal									$664,846
Bond	1.5%	%							$9,973
Subtotal									$674,818
Estimating Contingency	10.0%	%							$67,482
Total Probable Construction Cost									**$742,300**

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)

Location: Fort Irwin, California	Region No. 4	Project No.	PN 351
Project Title: FY96 Water Conservation Study		Fiscal Year	FY96
Discrete Portion: Additional Water Storage & Pump Load Shifting		Preparer:	KELLER & GANNON
Analysis Date: February, 1997 (Rev. April 1997)	Economic Life 20	Years	

1. Investment Costs

A. Construction Costs		$742,300		
B. SIOH	5.5%	$40,827		
C. Design Cost	6.0%	$44,538		
D. Total Cost (1A+1B+1C)		$827,665		
E. Salvage Value of Existing Equipment			$0	
F. Public Utility Company Rebate			$0	
G. Total Investment (1D-1E-1F)				$827,665

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-11 Used for Discount Factors: July 1996

Energy Source	Cost $/MBTU	Saving MBTU/Yr(2)		Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.		0		$18,524	15.03	$278,412
B. Dist					17.48	$0
C. Natural Gas					15.81	$0
D. Propane					15.81	
E. Demand Savings		787	kW	$96,462	15.03	$1,449,824
F. Total				$114,986		$1,728,236

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($724)		
(1) Discount Factor (Table A)		14.34	
(2) Discounted Savings/Cost (3A x 3A1)			($10,382)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.		0		$0
b.				
c.				
d. Total	$0			$0

C Total Non Energy Discounted Savings (3A2+3Bd4) ($10,382)

4. First Year Dollar Savings (2F3+3A+(3Bd1/Economic Life)):	$114,262	
5. Simple Payback (1G/4):	7.24	Years
6. Total Net Discounted Savings (2F5+3C):	$1,717,854	
7. Savings to Investment Ratio (SIR) 5/1G:	2.08	

COMPUTATION SHEET

Keller & Gannon
Engineers Architects
Since 1941

Computed By:	BIH	**RECLAIM POTABLE (REVERSE OSMOSIS) FLUSH WATER**	**Project:**	Water Conservation Study, Fort Irwin
Checked By:			**Project No.**	16-403-21
Date:	4 March '97		**Sheet No.**	1 of 4
Revision:	April '97			

Background

The reverse osmosis (RO) plant produced demineralized water, principally to control the concentration of fluoride in drinking water at Fort Irwin. In the early 1980's, it was discovered that significant scaling was occurring on distribution piping. Copper and galvanized piping were being corroded and the asbestos concrete (AC) piping was having its lime leached out. In one case, the pH rose from about 7 to 10 in just 1/4 mile of AC piping. Several cases of toxic exposures to copper were encountered.

Based on recommendations from an Army investigation, chemical treatment of the RO water was commenced. Sodium silicate and sulfuric acid are used to control pH. Zinc orthophosphate is added to form a coating which fuses to the interior pipe surfaces, masking them from continued corrosion.

In order to keep the protective coating on the interior surfaces of RO water distribution piping, it necessary to maintain water flow. Most of the distribution system maintains enough flow due to consumption. However, several portions of the distribution system are at relative "dead-ends". Water does not flow enough to maintain the chemical coating and the metallic piping begins to corrode. Periodic flushes of metallic piping are performed from specific points to provide flow and to allow the coating to fuse to the pipe walls. The flush water is presently allowed to flow to the storm drainage system. Thus, water losses from these activities are significant.

Metallic piping serving the older family housing areas is being replaced with PVC piping along with building renovations. The corrosion problem in these areas will cease to be a problem for distribution system piping.

Proposed Water & Energy Conservation Retrofit

It is proposed to collect RO water distribution system flush water in water trucks for use in irrigation and/or for dust control. Water is presently dispensed from water trucks for these purposes, thus, the "saved" water represents a true savings.

The RO water system flush water can be flowed through fire hoses directly into top loading manholes of water trucks.

The proposed project will require additional administrative time to plan logistics of requiring water trucks to be scheduled along with RO system flushing crews and to identify areas needing irrigation and/or for dust control.

According to water system operators and administrators, the RO system is flushed at least every 3 months. A list of flush points provided by Johnson Controls (Installation Support Contractor) indicates there are some 41 points from which RO water is flushed. The number of points for each pipe size are summarized:

Pipe Dia.	Points	Pipe Dia.	Points	Pipe Dia.	Points
1/2-inch	1	1-1/2-inch	2	6-inch	1
3/4-inch	1	2-inch	10	unknown	15
1-inch	6	4-inch	5	Unknown assumed 2-inch	

COMPUTATION SHEET

Keller & Gannon
Engineers Architects
Since 1941

Computed By:	BIH	**RECLAIM POTABLE**	**Project:**	Water Conservation Study, Fort Irwin
Checked By:		**(REVERSE OSMOSIS)**	**Project No.**	16-403-21
Date:	4 March '97	**FLUSH WATER**	**Sheet No.**	2 of 4
Revision:	Apr-97			

Estimated Water Consumption from Flushing RO Distribution System

Water is flushed for 20 minutes each per flush point, every 3 months. Pressure is 60 psig per system operators. Then, based on Cameron Hydraulic Data, the flow rates and volumes are calculated below:

Cameron Hydraulic Data (see page 2-8):

$$Q = 19.636\ C\ d_1^2\ \text{Sq Rt}(h) \times \text{Sq Rt}(1 / (1 - (d_1 / d_2)^4)), \text{ where } d_1 / d_2 \text{ is greater than } 0.3$$

Where: Q = Flow, gpm
d_1 = Diameter of orifice or nozzle opening, inches
h = Differential pressure head at orifice, in feet of liquid
d_2 = Diameter of pipe in which orifice is placed, inches
C = Discharge coefficient (typical values from Cameron)

For a valve of the same size as the pipe, assume d_1 / d_2 is:	0.90
h, the head is converted from 60 psig, or:	138-feet
C, from Cameron Hydraulic Data is assumed to be:	0.60

Then flush rates are calculated below for the pipe sizes listed on the previous sheet:

Pipe Dia.	Calc. Flow (gpm)	% Full Flow	Duration	Volume	No. Ea.	Volume per Flush Cycle
1/2-inch	101	100%	20 Min	2,012 Gal	1	2,012 Gallons
3/4-inch	226	100%	20 Min	4,528 Gal	1	4,528 Gallons
1 -inch	402	100%	20 Min	8,049 Gal	6	48,294 Gallons
1 1/2-inch	906	100%	10 Min	9,055 Gal	2	18,110 Gallons
2 -inch	1,610	50%	7.5 Min	6,037 Gal	25	150,919 Gallons
4 -inch	6,439	25%	2 Min	3,220 Gal	5	16,098 Gallons
6 -inch	14,488	25%	2 Min	7,244 Gal	1	7,244 Gallons
Total Volume per Flushing Cycle						247,205 Gallons
Annual Volume, based on one flush per			**3 month**	**cycle:**		**988,819 Gallons per Year**

Additional Operation & Maintenance Costs

Collecting the flush water will require an extra worker and scheduling of water trucks. Assume that the added labor and administrative time is equivalent to 60 hours per quarter.

$26 /Hr x 240 Hr/Yr = $ 6,240 per Year

Assume that a water truck is available for about $10,000, used.

COMPUTATION SHEET

Keller & Gannon
Engineers Architects
Since 1941

Computed By: BIH	**RECLAIM POTABLE**	**Project:**	Water Conservation Study, Fort Irwin
Checked By:	**(REVERSE OSMOSIS)**		
Date: 4 March '97	**FLUSH WATER**	**Project No.**	16-403-21
Revision: Apr-97		**Sheet No.**	3 of 4

RO Water Production O&M and Energy Cost Savings

From calculations of RO Water Costs:

Cost per 100 cubic feet =	**$2.9967**	**$4.0058**	**/1000 gallons**
Component Costs: Electric Demand:		$1.2444	/1000 gallons
Electric Use:		$2.3689	/1000 gallons
O&M (25% of Cost Avoided):		$0.3925	/1000 gallons

Electric Demand Savings:	$1,230 /Yr Saved	$3,573	/Yr Electric Cost Saved
Electric Use Savings:	$2,342 /Yr Saved	Energy cost savings are based on average cost of:	
Water System O&M Savings:	$388 /Yr Saved	$0.0539	per kWh, including demand charges,

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)

Location: Fort Irwin, California Region No. 4 Project No. PN 351
Project Title: FY96 Water Conservation Study Fiscal Year FY96
Discrete Portion: Reclaim **Reverse Osmosis** System Flush Water Preparer: KELLER & GANNON
Analysis Date: March, 1997 (Rev. April 1997) Economic Life: 20 Years

Sheet No. 4 of 4

1. Investment Costs

A. Construction Costs		$10,000		
B. SIOH	5.5%	$550		
C. Design Cost	6.0%	$600		
D. Total Cost (1A+1B+1C)		$11,150		
E. Salvage Value of Existing Equipment			$0	
F. Public Utility Company Rebate			$0	
G. Total Investment (1D-1E-1F)				$11,150

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-11 Used for Discount Factors: July 1996

Energy Source	Cost $/MBTU	Saving MBTU/Yr(2)		Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$15.80	226		$3,573	15.03	$53,700
B. Dist					17.48	$0
C. Natural Gas					15.81	$0
D. Propane					15.81	$0
E. Demand Saving	$0.00	included	kW	$0	15.03	$0
F. Total				$3,573		$53,700

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($5,852)		
(1) Discount Factor (Table A)		14.34	
(2) Discounted Savings/Cost (3A x 3A1)			($83,916)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.		0		$0
b.				
c.				
d. Total	$0			$0

C Total Non Energy Discounted Savings (3A2+3Bd4) ($83,916)

4. First Year Dollar Savings (2F3+3A+(3Bd1/Economic Life)): ($2,279)
5. Simple Payback (1G/4): NA Years
6. Total Net Discounted Savings (2F5+3C): ($30,216)
7. Savings to Investment Ratio (SIR) 5/1G: NA

JOHNSON CONTROLS

Johnson Controls, Inc
Box 105123
Fort Irwin, California 92310-5123

Fort Irwin Installation Support Project

Date: 1/23/97

Number of pages including cover sheet: ____

To:

Blair Horst

Keller & Gannon

DATE REC'D: 1/23/97

TIME REC'D: 9:03

PROJECT No.: ____

ORIGINAL: BTH /FILE ____

Fax phone: 415-864-3681 — MR

COPY: ____

Phone: 415-621-1199

From: John R. Spangler	
Phone:	(619) 380- 5738
Fax phone:	(619) 380- 4595

Message: Good morning Blair; hope it's not too wet there. Here are the Reverse Osmosis flush points you requested. Also, the distribution flush points in case you need those as well. If you have any questions, please give Ken Alec or myself a call. Stay dry!

John R. Spangler

RO Flush Points

Bldg.-location-remarks

1.) 198 R.O. D.C. (Take Backflow valve apart to flush)
2.) 222 R.O. R.P. (~~Take Back~~flow valve apart to flush)
3.) 327 4th and B ? 337
4.) 493 4th & G
5.) 523 1st & South Loop
6.) 551 2nd & South Loop
7.) 573 3rd & South Loop
8.) [redacted]
9.) 687 (near) off Barstow
10.) 833 South loop 4"(near dust bowl shoppette)
11.) 860 depot Rd. 4" (inside fence)
12.) 983 (near)& Inner loop 4" (front)
13.) 1722 Goldstone & Pork Chop
14.) 1838 Normandy near school
15.) 2000 Bastogne & Salerno 2" (front)
16.) 2100 Bastogne & Shiloh 2" (front)
17.) 2300 Bastogne & Antieam 2" (front) disabled 2" valve
18.) 2400 Bastogne & Anzio 2" (front)
19.) 2600 Bastogne & St. Mikiel 2" (front)
20.) 2800 Bastogne & Yorktown 2" (front)
21.) [redacted]
22.) 3201 Omaha 1 1/2" (Take Backflow valve apart to flush)
23.) 3401 Tunisa and Tippecanoe 1"
24.) 3501 Tunisa & Wilderness 1" (front)
25.) 3607 Rhineland 1" (in box, front)

26.)3625 Rhineland-M.R Room

27.)3627 Rhineland 3/4" in M.R. Room

28.)3631 Rhineland & Goldstone (1 1/2" in box, front)

29.)3689 Plieku 4" (behind)

30.)3709 Monmouth (listed, but never found) ?

31.)3721 Ardenesse 4" (front)

32.)3746 Fredricksburg & Pork Chop 6" (front)

33.)3811 Sumner & Corrigedor 2" (front)

34.)3831 Buena Vista & Saratoga 2" (park across street)

35.)3840 Vera Cruz & Pork Chop

36.)3860 Red Pass Drive

37.)TS 23 Goldstone & Pork Chop (Goldstone front)

38.)3881 Granite Pass & Coyote Cove 2" (front)

39.)3905 Commander's Loop 1/2" Behind

40.)4048 Soda Mountain 2" (behind)

41.)5114 Blue Bell Ct. 1" (behind)

42.)5158 Craker Jack 1" (behind)

43.)5220 Gold Nugget 1" (front, in meter box)

COMPUTATION SHEET

Keller & Gannon
Engineers Architects
Since 1941

Computed By:	BIH	ICE PLANT WATER SAVINGS	**Project:**	Fort Irwin - Water Conservation
Checked By:	RCL	&		
Date:	24 Feb '97	PRECOOLING RETROFIT	**Project No.**	16-403-21
Revision:			**Sheet No.**	1 of 8

Background

The ice plant at Fort Irwin has a rated capacity of 50 tons per day. The ice plant, Building No. 887, is located contiguous to Building No. 882, a cold storage warehouse. The ice making skid is situated on an elevated platform, some 29 feet high. Sheets of ice made by the ice machine are broken and conveyed into the building and transferred to the rake. Broken sheet ice is further broken and sized prior to being bagged. Bagged ice is stored on pallets for truck pickup.

During the summer, the highest demand period, the plant is capable of producing only about 30 tons per day (TPD). This reduced capacity is due, in part, to too high a feed water temperature. Other problems include frequent jamming of the equipment. The feed water rises up a 2-inch diameter PVC pipe, One inch of fiberglass insulation is installed with an aluminum jacket. Potable water is supplied at about 71°F, but is raised to about 88°F before is reaches to the ice plant.

The ice sizer installed up-line of the bagging operation rejects particles too fine to be bagged. The fines, or "snow" are discharged from the process from a shoot protruding from the building. This snow is allowed to melt, runoff and evaporate. Inspection of the ice plant operations revealed several discharges of cold water. The ice making plant functions by sending a stream of water over freezing plates. Sheet ice formed on the plates is released by briefly reversing the freezing process to heat up the plates. Water is circulated from a basin below the ice making sheets. The basin is purged or allowed to overflow depending on water quality. At Fort Irwin, a continuous overflow of about 3 gpm is needed. The screw conveyor used to transfer the broken sheet ice into the building and rake is upward inclined, allowing the wet ice to drain; this conveyor is also washed down between cycles.

Nameplate Data

Manufacturer:	Turbo Refrigerating Co., Denton, Texas (817) 387-4301		
Model:	TIGAR 50FL SCE	Dimensions:	118" x 94" x 110"
24Hr Capacity:	50 Tons Ice per day, nominal	Water Pump:	2 @ 1 HP, Each
Refrigeration:	75 Tons	Feedwater Flow:	8 gpm
Ammonia:	24 gpm	FLA:	14 Amps

Proposed Water & Energy Conservation Retrofit

The snow and wastewater flows from the ice plant represent a potential source for waste heat recovery. It is proposed to collect these waste streams and precool feed water to the ice plant. It is anticipated that this action will partially solve the ice plant capacity shortfall. Additionally, it is proposed to utilize the wasted wash water and melted "snow" for irrigating a landscaped area. This action will utilize otherwise wasted water and provide a landscaped area at the building. The proposed retrofit will consist of:

1. "Snow" and waste water collection / heat exchanger tank.
2. Heat exchange coils or stipple plate mounted inside the tank.
3. Ice plant feed water piping modifications.
4. Waste water collection piping modifications.
5. Solar powered irrigation pump.
6. Concrete pad for the basin and transfer pump.
7. Landscaping and irrigation piping.

COMPUTATION SHEET

Keller & Gannon
Engineers Architects
Since 1941

Computed By:	BIH	ICE PLANT WATER SAVINGS	**Project:**	Fort Irwin - Water Conservation
Checked By:	RCL	&		
Date:	24 Feb '97	PRECOOLING RETROFIT	**Project No.**	16-403-21
Revision:			**Sheet No.**	2 of 8

Energy Required to Make Ice

50 Tons of Ice requires energy to lower the feed water temperature to 32°F from the rating standard 60°F, and energy for the phase change, with additional energy to sub cool the ice to 0°F. Energy needed to form 50 tons of ice at 0° from 60°F feed water is estimated based on the following:

Ice, Heat of Fusion:	144 BTU/Lb
Ice, Specific Heat:	0.465 BTU/Lb-°F @ -4°F
	0.468 BTU/Lb-°F @ -0°F, interpolated
	0.486 BTU/Lb-°F @ 25°F, interpolated
	0.487 BTU/Lb-°F @ 32°F

Heat to Lower feedwater to 32°F: [50 tons x 2000 Lb/ton + 3 gpm x 60 min x 24 Hrs] x (60°F-32°F) =
at rated conditions = 3,810,000 BTU (overflow of 3 gpm, continuous, see below)
Heat Needed for Fusion: 50 tons x 2000 Lb/ton x 144 BTU/Lb = 14,400,000 BTU
Heat Needed to Lower Ice to 0°F: 50 tons x 2000 Lb/ton x 0.468 (BTU/Lb-°F) x (32°F - 0°F) =
= 1,530,000 BTU

Total Heat to make 50 Tons 0°F Ice: 19,740,000 BTU (values rounded for display)

In order to control water quality in the ice formed, the circulation basin under the ice forming plates of the ice machine is normally purged periodically. With the water quality at Fort Irwin, a continuous overflow of about 3 gpm is used to control water quality.

At a capacity of 50 Tons per 24-hour day, waste water from the ice maker is estimated at:
4,320 gpd. Assume the waste water exits the reservoir at 32°F

Wash water from the screw conveyor was observed to be on continuously during site inspections over a 10 day period. The flow is estimated at an additional 1.0 gpm. Assuming that the flow can be stopped when the ice plant is idle, daily water consumption is assumed cut in half for overflow and wash water flowed to drain. Reduced daily use is estimated at: 2,880 gpd. This water, although not at freezing temperature, is chilled by contact with the ice shoot. Assume this water is at 45°F as it leaves the ice shoot.

According to the ice machine manufacturer, "snow" from the sizer, comprise about 10% of overall production. The "snow" discharged from the sizing operation at Fort Irwin is assumed at 7.5% of overall ice production. Based on 50 tons per day production, daily "snow" discharge is estimated about at: 7,500 ppd. Although the ice plant is run for ice at 0°F, to be conservative, it is assumed that "snow" is at 25°F.

Summary: Energy from Waste Water and "Snow" at Full Capacity (24 Hr/Day Operations)

Ice Maker Overflow	4,320 gdp	32 °F Water	(current operations discharge
Shoot Wash Water	1,440 gdp	45 °F Water	these flows 100% of the time)
"Snow"	7,500 Lb/Day	25 °F Ice	

Standard ratings for the ice plant are based on an entering water temperature of 60°F. With a feedwater temperature of 88°F, the cooling energy needed to provide 60°F feed water, when making 50 tons of ice, and using the flow ratios above, is estimated at: 3,810,000 BTU

Thus, heat lost from too high a feed temperature will reduce the capacity of the ice plant by about: 19.3%
This may be part of the reason why the plant is referred to as a 40 TPD plant rather than a 50 TPD facility.

COMPUTATION SHEET

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Checked By: RCL
Date: 24 Feb '97
Revision:

ICE PLANT WATER SAVINGS
&
PRECOOLING RETROFIT

Project: Fort Irwin - Water Conservation
Project No. 16-403-21
Sheet No. 3 of 8

Potential Heat Recovery for Pre-Cooling Feed Water (Ice Plant at Full Capacity)

The flows of waste water and ice are combined; the 45°F water will warm the ice slightly	
Assuming all the water is cooled to 32°F, the wash water cooling energy need is:	156,300 BTU/Day
The energy required to warm the ice from 25°F to 32°F is:	25,500 BTU/Day
Remaining Energy after Warming Ice to 32°F:	130,800 BTU/Day

This energy is available to melt the ice. At a heat of vaporization of 144 BTU/Lb,
the "Snow" melt energy required for 32°F is: 1,080,000 BTU/Day
Thus, 12% of the ice is melted, the remainder will stay ice until makeup water is cooled by the mixture.

The revised mixture consists of:

Water at 32°F:	5,869 gpd 32°F Water	
Ice at 32°F:	6,592 Lb/Day Ice, heat needed to melt it is:	949,200 BTU/Day

Feed water enters at 71°F; 17,736 gpd are fed to the Ice Plant
The feedwater temperature is lowered to: 64.6°F by melting the ice.

Now there are	17,736 gpd of feed water at	64.6°F	to be cooled by
	6,658 gpd of waste water at	32.0°F	available to cool the feed water

Precooling the feed water with this mixture, assuming a 5°F approach, feed water is cooled to: 60.7°F
before it enters the riser to the ice plant, almost the design temperature!

Heat gain for flow from the heat exchanger-basin, up the pipe, to the ice making machine, is estimated:
Piping is 2-inch diameter PVC with 2-inch fiberglass insulation and reflective aluminum jacket.

Design Summer Temperature (TM 5-785):	106°F	
Summer Cooling Degree-Days:	2,272	
Design Winter Temperature (TM 5-785):	26°F	Winter time heat gain is negligible
Winter Heating Degree-Days:	2,547	and is, thus, neglected

Insulation convective heat gain per 68°F air temperature and 45°F water: 28 BTUH/10 LF Pipe
(A/E Guide to Energy Conservation in Existing Buildings, Feb 1, 1980, US DOE, Figure 8-49)
Summer design temperature heat loss:

Figure 8-49 Temp. Difference:	45.0°F	water	68°F	air =	23°F
Actual Temperature Difference:	60.7°F	water	106°F	air =	45°F
Heat Gain Adjustment Factor:	45°F	÷	23°F	=	1.97
Adjusted Design Summer Heat Gain:					55.2 BTUH/10 LF Pipe
Summer Total Heat Gain:	15,823 BTU/10 LF Pipe per Year				

Preliminary takeoff of exposed piping: 86 LF; 136,074 BTU/Year Heat Gain

At 50 tons per day, and allowing for the ice maker basin waste, average flow is:	12.32 gpm
Temperature rise from the heat gain at design conditions:	0.1°F
Thus, the feed water entering the ice plant will be at about:	60.8°F

Although not at the rated temperature of 60°F, a considerable amount of overall energy savings is achieved.

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Checked By: RCL	&		
Date: 24 Feb '97	PRECOOLING RETROFIT	**Project No.**	16-403-21
Revision:		**Sheet No.**	4 of 8

Energy savings at the rated capacity of the ice maker is estimated: Energy difference between
88.0°F and 60.8°F feed water at 50 tons per day capacity is: 154,373 BTUH
This comprises 12.9 Refrigeration Tons of increased capacity.
At a COP of 3.52 this represents a 12.8 kW savings when the plant operates at 100%.

Annual Electrical Consumption and Cost Savings:

Recorded Ice Issues and purchases

Month	Tons Issued	Planned Production	Tons Purchased
Sep-95	771	600	171
Oct-95	309	246	63
Nov-95	124	124	0
Dec-95	63	0	63
Jan-96	77	77	0
Feb-96	105	105	0
Mar-96	123	123	0
Apr-96	251	250	1
May-96	481	391	90
Jun-96	447	250	197
Jul-96	1,186	715	471
Aug-96	1,036	850	186
12 Month Totals	4,973	3,731	1,242

250 days per year, assumed; weekday operations
14.9 TPD average production rate (calculated)
3,731 Tons per Year Produced

3,705,000 BTU/50 Tons Ice Cooling Energy Saved
23,550,000 BTU/50 Tons Ice Cooling Energy Used Presently

276,467,000 BTU Electric Power Saved = 81,004 kWH/Year Saved
$0.07295 /kWH-Yr Weekdays
Based on Week Day Power Rates $5,909 per Year Usage Costs Saved

Demand Saved at Same Production Rate 12.8 k W
$161.80 /kW-Yr Weekdays
$2,079 per Year Demand Costs Saved

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Date: 24 Feb '97
Revision:

ICE PLANT WATER SAVINGS
&
PRECOOLING RETROFIT

Project: Fort Irwin - Water Conservation
Project No. 16-403-21

Power Costs for Operating the Ice Plant:

Turbo, the manufacturer states that the COP of the ice plant is: 3.52

The plant is operated normally from 0800 to 1630 on week days.

Monthly Demand Charges per kW

	Summer On-Peak	Summer Mid-Peak	Summer Off-Peak	Winter Mid-Peak	Winter Off-Peak
Total Base Rate	$17.95	$2.70	$0.00	$0.00	$0.00
Non Time-Rltd	$6.60	$0.00	$0.00	$6.60	$0.00
Total Demand	**$24.55**	**$2.70**	**$0.00**	**$6.60**	**$0.00**

Note that demand charges are assessed for the whole month in each period with demand.

Electricity Consumption Rates ($/kWH)

Total Base Rate	0.09422	0.05847	0.03758	0.07071	0.03874

Operating Scenario, Weekdays

Summer 87 d/y	1200-1800	0800-1200	0000-0800	0800-2100	0000-0800	
Winter 173 d/y		1800-2300	2300-0000		2100-0000	
Present Operations, Weekdays Only						
Op Hrs/Day	4.5	4	0	8.5	0	**Annual Average**
Annual ($/kWH)	$36.89	$20.35	$0.00	$103.98	$0.00	**$0.07295 per kWH**
Continuous Operations, Weekdays Only						
Hr/D in Period	6	9	9	13	11	**Annual Average**
Annual ($/kWH)	$49.18	$45.78	$29.43	$159.03	$73.72	**$0.05723 per kWH**
Annual ($/kW)	$98.20	$10.80	$0.00	$52.80	$0.00	**$161.80 per kW**

Operation & Maintenance Costs for Precooling System

Operation and maintenance on the precooling system is expected to require no more than 6 man-days per year, or about: $1,356 per year labor; assume a similar investment in materials costs, for total annual O&M costs of: $2,712 per year.

COMPUTATION SHEET

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Checked By:	RCL	**Project No.**	16-403-21
Date:	24 Feb '97	**Sheet No.**	6 of 8
Revision:			

ICE PLANT WATER SAVINGS
&
PRECOOLING RETROFIT

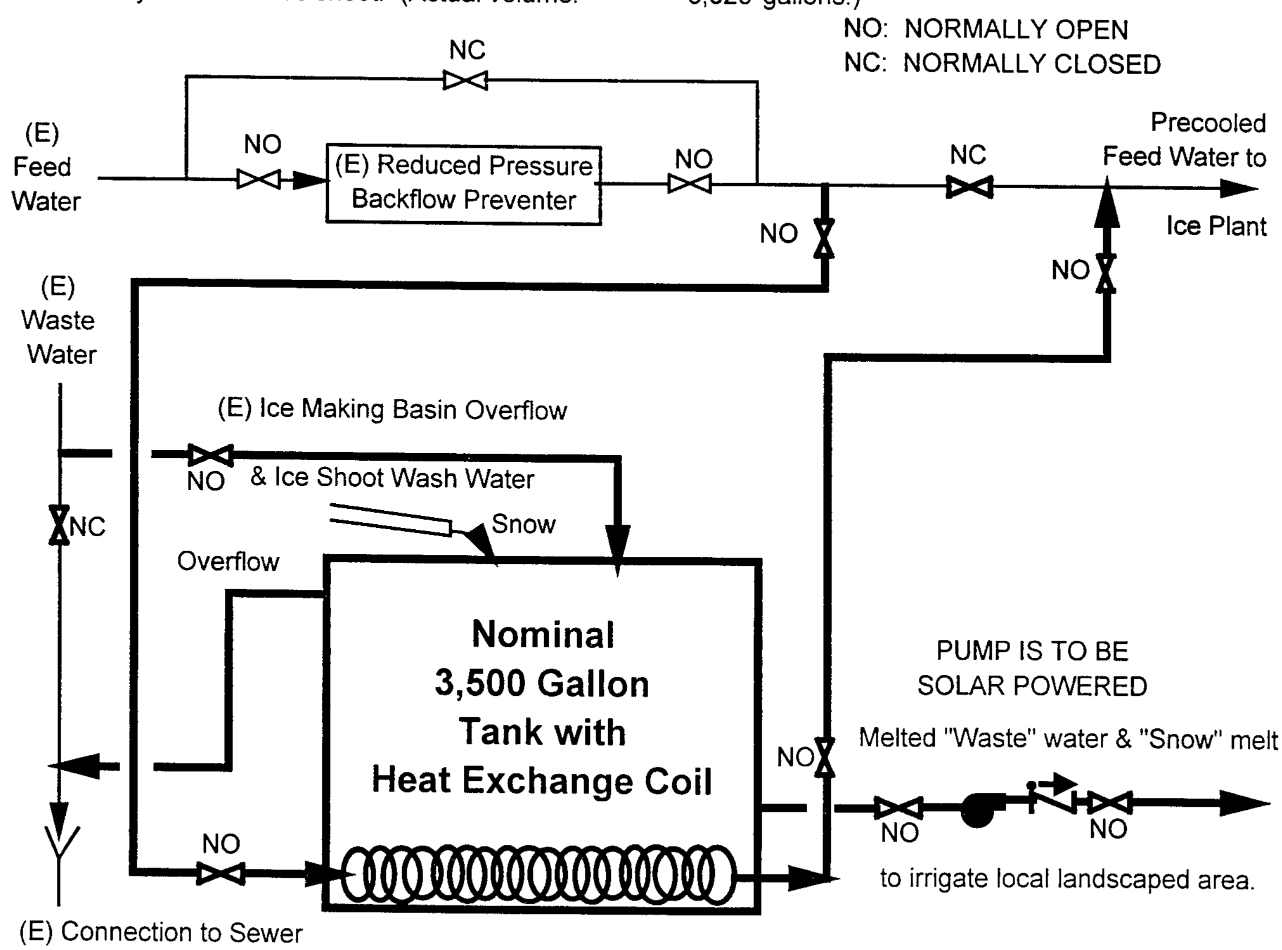
Concept Design of Heat Exchange Basin

Ice Plant Basin Overflow	4,320 gdp	32 °F Water
Ice Shoot Wash Water	1,440 gdp	45 °F Water
"Snow"	7,500 Lb/Day	25 °F Ice

The process consists of batch processing to produce ice and a continuous bagging operation. Water will be pumped out (or allowed to flow out) of the basin during the daylight hours, assisted by a solar powered pump. Thus, the plant must be designed to hold waste ice and water of at least 1/2 day's production.

Assuming the "Snow" has melted, the volume required is: 3,329 gallons

Space available will fit a 10-foot diameter tank with room for a footer between the ice machine supports and a condenser pad; tank height is: 5.67 feet high, install one 6-feet high. Place it directly below the ice shoot. (Actual volume: 3,525 gallons.)



CONSTRUCTION COST ESTIMATE	Date Prepared: Feb-97	Sheet 7 of 8
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: **Code A (no design competed)**
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Ice Plant Feed Water Precooling**	Estimator: **BIH**	Checked By: **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Investigation & Demolition									
Field Stake-out, Elevations	1.00	EA	$0	$0	$390	$390	$0	$0	$390
Drawing showing Boring Details	1.00	EA	$0	$0	$170	$170	$0	$0	$170
Report & Recommendations from Engineer	1.00	EA	$0	$0	$375	$375	$0	$0	$375
Mobilization/Demobilization, minimum	1.00	EA	$0	$0	$123	$123	$154	$154	$277
Clearing - Hand	0.06	Acre	$0	$0	$1,350	$77	$505	$29	$106
Subtotal, Site Investigation & Demolition				**$0**		**$1,058**		**$154**	**$1,212**
Excavation / Backfill / Compaction (3-inch deep, 50-Ft x 50-Ft Area)									
Excavate/Backfill by Hand	23.15	CY	$0	$0	$11.55	$267	$0	$0	$267
Compaction by Roller, Walking	23.15	CY	$0	$0	$2.95	$68	$0.86	$20	$88
Subtotal, Excavation / Backfill / Compaction				**$0**		**$336**		**$20**	**$356**
Tank Pad (Concrete)									
Forms in Place, Equip Foundation, 1 Use	21	SFCA	$2.27	$48	$7.60	$162	$0.26	$6	$216
Reinforcing Steel, in place	0.032	Ton	$0.16	$0	$0.22	$0	$0.00	$0	$0
Concrete In Place, nic Forms	1.8	CY	$63.50	$112	$21.50	$38	$0.37	$1	$150
Anchor Bolts, 3/4-inch Dia x 8-inch long	35	EA	$4.60	$159	$0.44	$15	$0.39	$13	$188
Subtotal, Tank Pad (Concrete)				**$319**		**$215**		**$20**	**$553**
Storage Tank and Appurtenances									
Storage Tank 3,500 gallons, interpolated	1	EA	$3,050	$3,050	$250	$250	$0.00	$0	$3,300
Cooling Coil, Tank Type	1	EA	$1,100	$1,100	$64	$64	$0.00	$0	$1,164
Special Construction for "Snow: Shoot	1	EA	$250	$250	$500	$500	Included		$750
Subtotal, Storage Tank and Appurtenances				**$4,400**		**$814**		**$0**	**$5,214**
Pump, Piping and Fittings									
PVC Pipe, Schedule 40, 2-inch	120	LF	$2.62	$314	$7.50	$900	$0.00	$0	$1,214
PVC Pipe Elbow, 2-inch	36	EA	$33.00	$1,188	$19.20	$691	$0.00	$0	$1,879
CPVC Ball Valve, Socket or Threaded, 2"	10	EA	$89.50	$895	$14.45	$145	$0.00	$0	$1,040
Ball Check, PVC, Socket or Threaded, 2"	1	EA	$82.00	$82	$14.45	$14	$0.00	$0	$96
Insulation, 2-inch Fiberglass w/ All Srvc Jkt	261	LF	$3.21	$838	$2.32	$606	$0.00	$0	$1,443
0.010-inch Aluminum Jacket, Tank & Piping	779	SF	$0.44	$343	$2.08	$1,619	$0.00	$0	$1,962
Irrigation Pump, 5 GPM, Say 1/40 HP	1	EA	$104.00	$104	$27.50	$28	$0.00	$0	$132
PVC Pipe, Schedule 40, 1/2-inch, incl. fittings	200	LF	$1.59	$318	$4.55	$910	$0.00	$0	$1,228
Irrigation Fittings, Allowance	1	LS	$250.00	$250	$500.00	$500	$0.00	$0	$750
Trenching with Chain Trencher, 4"Wx12"D	200	LF	$0.26	$52	$0.11	$22	$0.37	$74	$148
Subtotal, Pump, Piping and Fittings				**$4,384**		**$5,435**		**$74**	**$9,892**
Electrical Controls and Wiring									
High and Low Level Pump Control	1	EA	$500	$500	$250	$250	$0	$0	$750
Time Clock	1	EA	$118.00	$118	$67	$67	$0	$0	$185
Photvoltaic Array and Inverter, 25W	1	EA	$300	$300	$75.00	$75	$0	$0	$375
Disconnect Switch	1	EA	$49.50	$50	$75.00	$75	$0	$0	$125
Subtotal, Electrical Controls and Wiring				**$968**		**$467**		**$0**	**$1,435**
Subtotal				$10,070		$8,362		$282	$18,715
California Sales Tax	7.75%	%		$780				$22	$802
Subtotal									$19,517
Contractor OH & Profit	25.0%	%							$4,879
Subtotal									$24,396
Bond	1.5%	%							$366
Subtotal									$24,762
Estimating Contingency	10.0%	%							$2,476
Total Probable Construction Cost									$27,238

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)

Location: Fort Irwin, California — Region No. 4 — Project No. PN 351
Project Title: FY96 Water Conservation Study — Fiscal Year FY96
Discrete Portion: Ice Plant Feed Water Precooling Retrofit — Preparer: KELLER & GANNON
Analysis Date: February, 1997 — Economic Life: 20 Years

ANALYSIS BASED ON CURRENT PRODUCTION RATES

1. Investment Costs

A. Construction Costs		$27,238		
B. SIOH	5.5%	$1,498		
C. Design Cost	6.0%	$1,634		
D. Total Cost (1A+1B+1C)		$30,371		
E. Salvage Value of Existing Equipment			$0	
F. Public Utility Company Rebate			$0	
G. Total Investment (1D-1E-1F)				$30,371

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-11 Used for Discount Factors: July 1996

Energy Source	Cost $/MBTU	Saving MBTU/Yr(2)		Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$21.37	276		$5,909	15.03	$88,813
B. Dist					17.48	$0
C. Natural Gas					15.81	$0
D. Propane					15.81	$0
E. Demand Saving	$161.80	12.8	kW	$2,079	15.03	$31,248
F. Total				$7,988		$120,061

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($2,712)		
(1) Discount Factor (Table A)		14.34	
(2) Discounted Savings/Cost (3A x 3A1)			($38,890)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.		0		$0
b.				
c.				
d. Total	$0			$0

C Total Non Energy Discounted Savings (3A2+3Bd4) — ($38,890)

4. First Year Dollar Savings (2F3+3A+(3Bd1/Economic Life)):	$5,276	
5. Simple Payback (1G/4):	5.76	Years
6. Total Net Discounted Savings (2F5+3C):	$81,171	
7. Savings to Investment Ratio (SIR) 5/1G:	2.67	

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COMPUTATION SHEET

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Computed By:	BIH	**RESERVOIR REPAIR**	**Project:**	Fort Irwin - Water Conservation
Checked By:	RCL	**AND 220 UNIT HOUSING AREA**		
Date:	March 1997	**HEAT PUMP COOLING**	**Project No.**	16-403-21
Revision:	April 1997	**MODIFICATION**	**Sheet No.**	1 of 6

Background

The one million gallon underground water tank, the original water supply tank for Fort Irwin, has reportedly started to leak because the tar seals between concrete slabs have deteriorated and are melting away due to increased water temperature. The increased temperature is due to the recent installation of water-source heat pumps to serve the nearby 220-unit family housing expansion. The heat pumps utilize the water tank water as a heat sink. This arrangement is not unusual. However, the Fort Irwin water supply temperature exceeds that of most other areas where wells are the water source. Water pumped from wells serving Fort Irwin provide about 71 degrees F water whereas most wells provide water temperatures at least 20 degrees F cooler. Starting from a warmer temperature, water temperatures measured in the storage tank have exceeded 85 degrees F.

In order to correct the situation and to provide proper cooling and heating to the 220- unit family housing, it is proposed to reseal and line the reservoir and to construct a water cooling tower to serve the family housing area heat pump system.

Proposed Water & Energy Conservation Retrofit

In order to seal the reservoir properly, the basin must be drained and cleaned out prior to installing a liner:

1. Drain reservoir by utilizing it without refilling.
2. Shovel out accumulated silt and debris.
3. Patch and repair concrete floor and walls as needed.
4. Install plastic lining material on floor and to at least 12-inches above the high water level.

To remove the source of heating from the reservoir, install a cooling tower.

1. Install cooling tower, intercepting the circulating water line from the heat exchanger building to the reservoir.
2. Provide power from the heat exchanger building

Reservoir Liner Area Calculation

Reservoir Volume:	1,000,000 Gallons = 133,672 CF	
Reservoir Depth (HW-LW):		10 FT
Reservoir Floor Area:		13,367 SF
Wall Area (Allow 2 Ft Overlap):		5,550 SF
Total Wetted Surface Area		18,917 SF
Allowance for scrap		1,892 SF
Total Liner Required		20,808 SF

Cooling Tower Sizing Calculations

The heat pumps are installed for a 220-unit family housing project.

The new units average about 1,500 SF each; at a cooling capacity of 400 SF per ton, total tonnage of the heat pumps is estimated at: 825 Tons

Assume a diversity factor of 0.70, thus the cooling tower capacity must b 580 Tons

Water Loss Calculation

Floor Area: 13,367 SF
Length of Sides: 116 LF

Assume leakage through cracks 1/32-inch thick every 20-feet: 1,246 LF
Leakage is estimated at 50 gpd for a 1/32 inch hole at 60 psi. A foot of crack at a 7.5-Foot average head wound be: 1,039 GPD/LF

Assuming that only 10% of the cracks are leaking at this rate, daily losses could total: 129,501 GPD

Annual water losses are, thus: 47.27 MGY

Water Production O&M and Energy Cost Savings

From calculations of Domestic Water Costs:

Cost per 100 cubic feet = $0.4064 $0.5433 per 1000 Gallons

Component Costs:

Electric Demand:	$0.2398	/1000 gallons	
Electric Use:	$0.1783	/1000 gallons	
O&M:	$0.1252	/1000 gallons	(Assumes 25% Cost Avoidance)

Total Water Saved	47,268	x 1,000 gallons/year	$25,680	per year saved, or
Electric Demand Savings:	$11,334	/Yr Saved =	70.05 kW Saved @	$161.80 /kW-Year
Electric Use Savings:	$8,430	/Yr Saved =	156,307 kWH Saved	@ $0.05393 /kWH
Water O&M Savings:	$5,917	/Yr Saved		

Cooling Tower Energy Consumption

The cooling tower represents an additional energy user for the heating and cooling systems serving the 220-unit family housing project. Rough sizing from above calculations places the cooling tower size at about: 580 Tons

Select BAC MN: 3205, 3 each with 15 HP Fans.
Connect to variable frequency drives to follow the load.

Cooling Degree Days/Year:	2,272	Design Outdoor Temperature:	106°F
Heating Degree Days per Year:	2,547	Design Outdoor Temperature:	26°F
(per TM 5-785)	Summer	Design Indoor Temperature:	68°F
	Winter	Design Indoor Temperature:	78°F

Cooling Full Load Hours:	(Deg-Hrs/Yr) / Delta T = Full Load Hours =	1,947
Heating Full Load Hours:	(Deg-Hrs/Yr) / Delta T = Full Load Hours =	2,351
Full Load Hours per Year		4,299

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Computed By:	BIH	**RESERVOIR REPAIR**	**Project:**	Fort Irwin - Water
Checked By:	RCL	**AND 220 UNIT HOUSING AREA**		Conservation
Date:	March 1997	**HEAT PUMP COOLING**	**Project No.**	16-403-21
Revision:	Apr-97	**MODIFICATION**	**Sheet No.**	3 of 6

Cooling Tower Fan Energy Consumption

Demand Charge Increase: 3 x 15 HP Motors x 0.746 kW/HP =	33.57 kW =	
Annual Electric Demand Additional Costs	$5,432	$161.80 /kW-Year
Electric energy Consumption Increase: Full Load Hours x kW =	144,301 kWh/Yr =	
Annual Electric Energy Use Additional Costs	$7,782	@ $0.05393 /kWH

O&M Costs: Assume 5% of equipment cost per year: $3,140 per year

Cooling Tower Make-up Water Consumption

Assume 90°F cooling water retrun temperature.
At design summer conditions, the wet bulb temperature is 68°F; with an approach temperature of 5°F, the cooling tower temperature diffierence will be 90°F - 73°F = 17°

Evaporative losses, 1% for 10°F temperature difference: 17°F/10°F x 1% = 1.7%
Windage Losses: 1%
Blowdown Losses: assume 2% for high TDS water
Cooling Tower Makeup: 4.70%

Cooling Tower Circulation Rate: Equivalent of 580 RT for 4,299 Hours per Year:
Makeup Water Requirements are: 9,745,618 Gallons per Year

Electric Demand:	$0.2398	/1000 gallons	
Electric Use:	$0.1783	/1000 gallons	
O&M:	$0.1252	/1000 gallons	(Assumes 25% Cost Avoidance)

Total Added Water Use:	9,746 x 1,000 gallons/year		$5,295	per year cost, or
Electric Demand Usage:	$2,337 /Yr Used =	14.44 kW Used @		$161.80 /kW-Year
Electric Use Usage:	$1,738 /Yr Used =	32,227 kWH Used		@ $0.05393 /kWH
Water O&M Added:	$1,220 /Yr Used			

Cooling Tower Water Treatment Costs

Water treatment is needed for biological and scaling control. Assume this cost is about 0.5% of cooling tower equipment costs per year. Cooling tower equipment: $83,404 x 0.05 = $4,170

COMPUTATION SHEET

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Computed By:	BIH	**RESERVOIR REPAIR AND 220 UNIT HOUSING AREA HEAT PUMP COOLING MODIFICATION**	**Project:**	Fort Irwin - Water Conservation
Checked By:	RCL		**Project No.**	16-403-21
Date:	March 1997		**Sheet No.**	4 of 6
Revision:	April 1997			

Annual Cost Savings Summary

Description	**Electric Demand**	**Electric Usage**	**Operations & Maintenance**
Water Savings	$11,334	$8,430	$5,917
Cooling Tower Fans	($5,432)	($7,782)	($3,140)
Cooling Tower Makeup	($2,337)	($1,738)	($1,220)
Cooling Tower Treatment	$0	$0	($4,170)
Overall Savings	$3,565	($1,091)	($2,613)

Annual Energy Savings Summary

Description	**Electric Demand**	**Electric Usage**
Water Savings	70.05 kW	156,307 kWh
Cooling Tower Fans	(33.57) kW	(144,301) kWh
Cooling Tower Makeup	(14.44) kW	(32,227) kWh
Overall Savings	22.04 kW	(20,221) kWh
		(69.02) Million BTU/Year Saved

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar-97	Sheet 5 of 6
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Reservoir Repair & 220 Unit FH Area Heat Pump Cooling Mod.**	Estimator: **BIH**	Checked By: **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Clean-up of Reservoir Floor									
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Excav/Load, Bulk, 150 Haul, Clay	83	CY	$0.00	$0	$4.07	$336	$3.93	$325	$660
Haul Debris/Silt 12 CY Truck 10 mi RT	83	CY	$3.48	$287	$8.80	$726	$12.28	$1,013	$2,027
Subtotal: Clean-up of Reservoir Floor				**$287**		**$1,294**		**$1,629**	**$3,210**
Restore Reservoir Floor and Install PVC Lining									
Patching Concrete; 1/4-inch Thick	13,367	SF	$0.90	$12,030	$1.74	$23,259	$0.00	$0	$35,289
Liner, PVC 48 mil thick	134	CSF	$93.50	$12,498	$16.25	$2,172	$0.00	$0	$14,670
Subtotal: Restore Reservoir Floor and Install PVC Lining				**$24,529**		**$25,431**		**$0**	**$49,960**
Cooling Tower Installation									
Cooling Tower, 205 Tons	3	EA	$18,450	$55,350	$1,768	$5,304	$0.00	$0	$60,654
Piping and Pumps	1	EA	$28,054	$28,054	$12,055	$18,083	$0.00	$0	$46,137
Foundation Concrete Slab	8	CY	$107	$904	$72	$604	$1.00	$8	$1,516
Startup and Mods to Existing System	1	EA	$5,000	$5,000	$15,000	$15,000	$0.00	$0	$20,000
VFD for Cooling Tower Fans	3	EA	$3,100	$9,300	$540	$1,620	$0.00	$0	$10,920
Conduit and Wiring	3	EA	$1,500	$4,500	$4,500	$13,500	$0.00	$0	$18,000
Startup and Mods to Existing System	1	EA	$5,000	$5,000	$15,000	$15,000	$0.00	$0	$20,000
Subtotal, PVC Pipe				**$108,108**		**$69,111**		**$8**	**$177,227**
Mechanical Subcontractors Overhead & Profit			10.0%	$10,811	50.0%	$34,556	10.0%	$1	$45,368
Subtotal				$143,734		$130,392		$1,638	$275,765
California Sales Tax	7.75%	%		$11,139				$127	$11,266
Subtotal									$287,031
Contractor OH & Profit	25.0%	%							$71,758
Subtotal									$358,789
Bond	1.5%	%							$5,382
Subtotal									$364,171
Estimating Contingency	20.0%	%							$72,834
Total Probable Construction Cost									$437,005

Life Cycle Cost Analysis Summary
Energy Conservation Investment Program (ECIP)

Location: Fort Irwin, California Region No. 4 Project No. PN 351
Project Title: FY96 Water Conservation Study Fiscal Year FY96
Discrete Portion: Line Underground Reservoir; Install Cooling Tower for 220-Unit Family Housing Preparer: KELLER & GANNON
Analysis Date: February, 1997 (Rev. April 1997) Economic Life: 20 Years

1. Investment Costs

A. Construction Costs		$437,005		
B. SIOH	5.5%	$24,035		
C. Design Cost	6.0%	$26,220		
D. Total Cost (1A+1B+1C)		$487,261		
E. Salvage Value of Existing Equipment			$0	
F. Public Utility Company Rebate			$0	
G. Total Investment (1D-1E-1F)				$487,261

2. Energy Savings (+)/Cost(-):

Date of NISTIR 85-3273-11 Used for Discount Factors: July 1996

Energy Source	Cost $/MBTU	Saving MBTU/Yr(2)		Annual $ Savings(3)	Discount Factor(4)	Discounted Savings(5)
A. Elec.	$ 15.80	(69.02)		($1,090)	15.03	($16,390)
B. Dist					17.48	$0
C. Natural Gas					15.81	$0
D. Propane					15.81	$0
E. Demand Saving	$161.80	22.0	kW	$3,565	15.03	$53,588
F. Total				$2,475		$37,198

3. Non Energy Savings (+) or Cost (-):

A. Annual Recurring (+/-)	($2,613)		
(1) Discount Factor (Table A)		14.34	
(2) Discounted Savings/Cost (3A x 3A1)			($37,475)

B. Non Recurring Savings (+) or Cost (-)

Item	Savings(+) Cost(-)(1)	Year of Occur. (2)	Discount Factor(3)	Discounted Savings(+)Cost(-)(4)
a.		0		$0
b.				
c.				
d. Total	$0			$0

C Total Non Energy Discounted Savings (3A2+3Bd4) ($37,475)

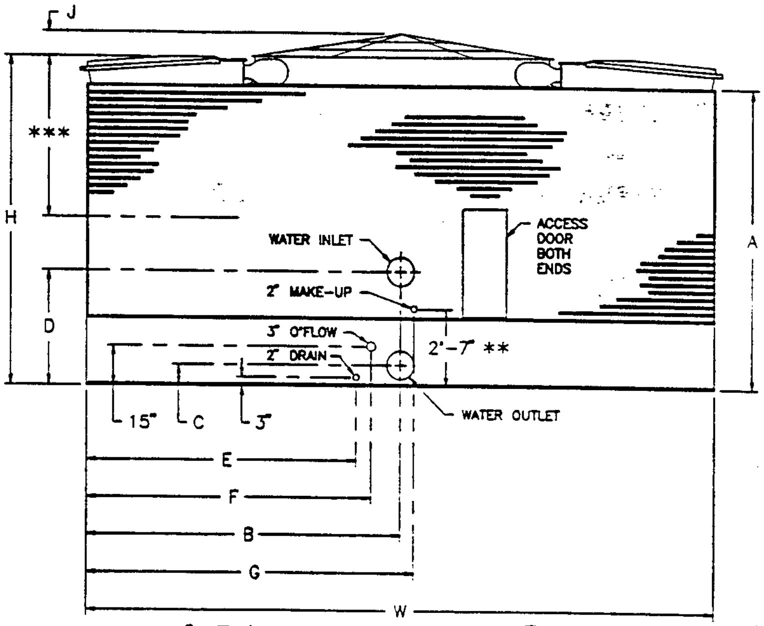
4. First Year Dollar Savings (2F3+3A+(3Bd1/Economic Life)):	($138)	
5. Simple Payback (1G/4):	NA	Years
6. Total Net Discounted Savings (2F5+3C):	($277)	
7. Savings to Investment Ratio (SIR) 5/1G:	NA	

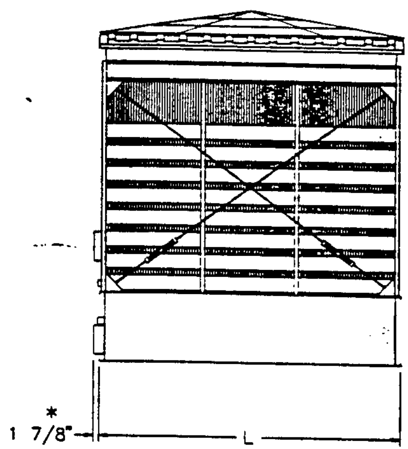
ENGINEERING DATA

SHEET 6 OF 6

Do not use for construction. Refer to factory certified dimensions.
This brochure includes data current at time of publication which should be reconfirmed at the time of purchase.

Single Cell Units





*3935 thru 31055—½"
**3586 thru 31055—2'10"
***3586 thru 31055 ship in two sections per cell, the top section is the heaviest.
Heights are: 3586 thru 3685—6'7⅞"
3707 thru 31055—9'3⅞"

3 EA MN: 3205, 15 HP FAN

VFD $2800 EA.

MODEL NO.	NOMINAL TONS[1]	MOTOR HP	CFM	WEIGHTS (LBS.) OPERATING	SHIPPING	HEAVIEST SECTION	DIMENSIONS L	W	H	A	B	C	D	E	F	G	J	INLET CONN. SIZE	OUTLET CONN. SIZE
3130	130	5	37,300	10,450	4,140	4,140	6'1¼"	17'1½"	8'10"	7'11½"	8'6¾"	7 1/16"	3'4 9/16"	7'1½"	7'7¼"	8'11 15/16"	5⅞"	6"	6"
3150	150	7.5	42,350	10,480	4,170	4,170	6'1¼"	17'1½"	8'10"	7'11½"	8'6¾"	7 1/16"	3'4 9/16"	7'1½"	7'7¼"	8'11 15/16"	5⅞"	6"	6"
3165	165	10	46,550	10,490	4,180	4,180	6'1¼"	17'1½"	8'10"	7'11½"	8'6¾"	7 1/16"	3'4 9/16"	7'1½"	7'7¼"	8'11 15/16"	5⅞"	6"	6"
3184	184	15	52,800	10,560	4,250	4,250	6'1¼"	17'1½"	8'10"	7'11½"	8'6¾"	7 1/16"	3'4 9/16"	7'1½"	7'7¼"	8'11 15/16"	5⅞"	6"	6"
3185	185	10	53,900	10,830	4,510	4,510	6'1¼"	17'1½"	10'2"	9'3½"	8'6¾"	7 1/16"	3'4 9/16"	7'1½"	7'7¼"	8'11 15/16"	7⅞"	6"	6"
→ 3205	205	15	61,200	10,900	4,580	4,580	6'1¼"	17'1½"	10'2"	9'3½"	8'6¾"	7 1/16"	3'4 9/16"	7'1½"	7'7¼"	8'11 15/16"	7⅞"	6"	6"
3213	213	7.5	64,100	14,040	5,460	5,460	7'9⅝"	18'0½"	10'2"	9'3½"	9'0¼"	8 1/16"	3'5 9/16"	7'7"	8'0¾"	9'5 7/16"	7⅞"	8"	8"
3235	235	10	70,800	14,050	5,470	5,470	7'9⅝"	18'0½"	10'2"	9'3½"	9'0¼"	8 1/16"	3'5 9/16"	7'7"	8'0¾"	9'5 7/16"	7⅞"	8"	8"
3269	269	15	80,750	14,120	5,540	5,540	7'9⅝"	18'0½"	10'2"	9'3½"	9'0¼"	8 1/16"	3'5 9/16"	7'7"	8'0¾"	9'5 7/16"	7⅞"	8"	8"
3294	294	20	88,300	14,140	5,560	5,560	7'9⅝"	18'0½"	10'2"	9'3½"	9'0¼"	8 1/16"	3'5 9/16"	7'7"	8'0¾"	9'5 7/16"	7⅞"	8"	8"
3315	315	25	95,000	14,190	5,610	5,610	7'9⅝"	18'0½"	10'2"	9'3½"	9'0¼"	8 1/16"	3'5 9/16"	7'7"	8'0¾"	9'5 7/16"	7⅞"	8"	8"
3341	341	15	99,400	19,010	7,080	7,080	9'9¼"	20'0½"	10'2"	9'3½"	10'0¼"	9⅛"	3'6⅝"	8'7"	9'0¾"	10'5 7/16"	9⅜"	10"	10"
3373	373	20	108,700	19,030	7,100	7,100	9'9¼"	20'0½"	10'2"	9'3½"	10'0¼"	9⅛"	3'6⅝"	8'7"	9'0¾"	10'5 7/16"	9⅜"	10"	10"
3400	400	25	116,550	19,080	7,150	7,150	9'9¼"	20'0½"	10'2"	9'3½"	10'0¼"	9⅛"	3'6⅝"	8'7"	9'0¾"	10'5 7/16"	9⅜"	10"	10"
3424	424	30	123,550	19,100	7,170	7,170	9'9¼"	20'0½"	10'2"	9'3½"	10'0¼"	9⅛"	3'6⅝"	8'7"	9'0¾"	10'5 7/16"	9⅜"	10"	10"
3427	427	20	124,450	25,670	8,410	8,410	11'9¾"	20'6½"	10'2"	9'3½"	10'3¼"	9⅛"	3'3 9/16"	8'10"	9'3¾"	10'10 1/16"	10⅜"	10"	10"
3458	458	25	133,450	25,720	8,460	8,460	11'9¾"	20'6½"	10'2"	9'3½"	10'3¼"	9⅛"	3'3 9/16"	8'10"	9'3¾"	10'10 1/16"	10⅜"	10"	10"
3485	485	30	142,200	25,740	8,480	8,480	11'9¾"	20'6½"	10'2"	9'3½"	10'3¼"	9⅛"	3'3 9/16"	8'10"	9'3¾"	10'10 1/16"	10⅜"	10"	10"
3514	514	30	143,800	26,430	9,170	9,170	11'9¾"	20'6½"	11'6"	10'7½"	10'3¼"	10⅛"	3'4 9/16"	8'10"	9'3¾"	10'10 1/16"	10⅜"	12"	12"
3560	560	40	157,550	26,690	9,430	9,430	11'9¾"	20'6½"	11'6"	10'7½"	10'3¼"	10⅛"	3'4 9/16"	8'10"	9'3¾"	10'10 1/16"	10⅜"	12"	12"
3586	586	30	166,050	29,280	12,000	6,410	11'9¾"	22'0½"	12'10⅝"	12'0⅛"	11'0¼"	10⅛"	9'8"	9'7"	10'0¾"	11'7"	11⅜"	12"	12"
3642	642	40	181,800	29,540	12,260	6,670	11'9¾"	22'0½"	12'10⅝"	12'0⅛"	11'0¼"	10⅛"	9'8"	9'7"	10'0¾"	11'7"	11⅜"	12"	12"
3685	685	50	195,000	29,600	12,320	6,730	11'9¾"	22'0½"	12'10⅝"	12'0⅛"	11'0¼"	10⅛"	9'8"	9'7"	10'0¾"	11'7"	11⅜"	12"	12"
3707	707	40	193,800	34,660	13,170	7,570	11'9¾"	22'0½"	15'6⅝"	14'8⅛"	11'0¼"	10⅛"	9'8"	9'7"	10'0¾"	11'7"	11⅜"	12"	12"
3758	758	50	207,800	34,720	13,230	7,630	11'9¾"	22'0½"	15'6⅝"	14'8⅛"	11'0¼"	10⅛"	9'8"	9'7"	10'0¾"	11'7"	11⅜"	12"	12"
3803	803	60	220,150	34,880	13,390	7,790	11'9¾"	22'0½"	15'6⅝"	14'8⅛"	11'0¼"	10⅛"	9'8"	9'7"	10'0¾"	11'7"	11⅜"	12"	12"
3813	813	50	221,550	35,820	14,340	7,650	11'9¾"	22'0½"	18'2⅝"	17'4⅛"	11'0¼"	10⅛"	11'0"	9'7"	10'0¾"	11'7"	11⅜"	12"	12"
3860	860	60	235,000	35,980	14,500	7,810	11'9¾"	22'0½"	18'2⅝"	17'4⅛"	11'0¼"	10⅛"	11'0"	9'7"	10'0¾"	11'7"	11⅜"	12"	12"
3935	935	50	255,400	44,270	16,860	8,850	13'11⅛"	24'0½"	19'2⅝"	17'4⅛"	12'0¼"	10¾"	11'0"	10'7"	11'0¾"	12'7"	13⅜"	14"	14"
3990	990	60	270,700	44,430	17,020	9,010	13'11⅛"	24'0½"	19'2⅝"	17'4⅛"	12'0¼"	10¾"	11'0"	10'7"	11'0¾"	12'7"	13⅜"	14"	14"
31055	1055	75	290,050	44,480	17,070	9,060	13'11⅛"	24'0½"	19'2⅝"	17'4⅛"	12'0¼"	10¾"	11'0"	10'7"	11'0¾"	12'7"	13⅜"	14"	14"

Notes: 1. Nominal tons are defined as 3 gpm of water per ton, cooled from 95°F to 85°F with a 78°F entering wet bulb temperature.
Unless otherwise indicated, all connections 3" and smaller are MPT. Connections 4" and larger are beveled-for-welding and suitable for grooved connections.

E-49

APPENDIX F

Phased Pipe Replacements

APPENDIX F
Table of Contents

Revised April 1997

Table F-1
Summary of Industrial Area
Domestic Water Distribution System Pipe Replacements

Industrial Area Description	Total Cost	Year Built	Priority	Materials	Remarks
Area A - Inner Loop Road, Goldstone to 5th	$252,908	1966	4	AC	Meter & PRV Valve Boxes noted @ 1966
Area B - Avenue B, Industrial Area, Complete	$166,684	1966 ?	4	AC	Meter & PRV Valve Boxes noted @ 1966
Area C - Barstow Road - Langford to 7th	$290,519	1956 ?	2	AC	Based on data provided for nearby piping
Area D - 5th - 7th / Barstow - Avenue B	$85,460	1956 ?	2	AC	Based on data provided for nearby piping
Area E - 4th - 5th / Barstow to Avenue B	$243,960	1956	2	AC	
Area F - 3rd-1st / Barstow to Avenue B	$120,321	1956	2	AC & Transite	
Area G - Langford-1st / Barstow - Avenue B	$175,314	1966	4	AC	Meter & PRV Valve Boxes noted @ 1966
Area H - 1 Million Gal UST Lines from Ave B	$392,055	1952 ?	1	CI	Only one of 2 pipes identified
Area I - Inner Loop - Ave B / 5th - Goldstone	$229,006	1956	2	AC & Transite	Transite on Langford Road
Area J - Vehicle Maint. Shops, Barstow Rd	N/A	1985	-	-	NOT DONE, NEW PIPING
Area K - Bicycle Lake Booster to 7th	N/A	1967	-	AC	NOT DONE. PIPING NOT LEAKING & IN GOOD SHAP
Area L - Bicycle Lake Booster / 7th to Tanks	N/A	1967	-	AC	NOT DONE. PIPING NOT LEAKING & IN GOOD SHAP
Area M - Barstow-7th / Sanitary - Avenue F	$230,469	1965	4	AC	
Area N - 2nd - 5th / Barstow - Avenue F	$557,049	1956	2	AC	
Area O - Barstow-Langford / 2nd - Avenue F	$72,343	1956	2	AC	
Area P - Depot Loop & Road off Langford Rd	$402,030	1967	5	AC	
Area Q - Veh. Maint. Shops North of Langford	$704,345	1967 ?	5	AC ?	"Recent" newer facilities
Area R - Lanford Road / Avenue F to ASD	$635,950	1967 ?	5	AC ?	
Area S - South Loop Road, Langford to North	$161,781	1952	1	AC	Depth: 39-inches
Area T - 5th - Langford / Ave F to South Loop	$615,376	1952	1	AC	Depth: 39-inches
Area U - Langford Road to Avenue F	$185,160	1967	-	AC	
Area V - 5th - Langford / Ave F - Ave G	$637,177	1952	1	AC	Depth: 39-inches
Area W - 5th from S. Loop Treatment Plant	$207,799	1959	3	GI	

The above table lists discrete portions of the Industrial Area domestic water distribution system together with pipe materials, approximate year of construction and estimated cost of replacement with Schedule 80 PVC piping. The priority for replacement assigned to each area of the distribution system is tied to the age of the existing piping, with distribution mains installed in 1952 having the highest priority (1) and mains installed in 1967 having the lowest priority (5). Phased pipe replacements should be coordinated with planned road widening and repair projects.

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area A** - Inner Loop Road, Goldstone to 5th	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	2,780	LF	$0.03	$83	$0.54	$1,501	$0.00	$0	$1,585
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	28	EA	$0.00	$0	$25.00	$700	$31.40	$879	$1,579
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	3,336	LF	$0.38	$1,268	$1.38	$4,604	$1.06	$3,536	$9,408
Saw Cut Concrete (10-inch depth)	1,112	LF	$4.20	$4,670	$6.80	$7,562	$5.20	$5,782	$18,014
Pavement Removal, Bituminous to 6"	556	SY	$2.20	$1,223	$2.98	$1,657	$5.18	$2,880	$5,760
Concrete Removal, Rod Reinforced	185	SY	$4.61	$854	$6.25	$1,158	$10.86	$2,013	$4,025
Haul Pavements 12 CY Truck 10 mi RT	144	CY	$3.48	$502	$8.80	$1,269	$12.28	$1,770	$3,540
Subtotal, Survey, Site Investigation & Demolition				**$8,601**		**$19,617**		**$17,152**	**$45,370**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	167	CY	$0.00	$0	$11.55	$1,932	$0.00	$0	$1,932
Compaction by Roller, Walking	502	CY	$0.00	$0	$2.95	$1,481	$0.86	$432	$1,912
Trench: 40 HP, Riding, 16"W 36"D	2,780	LF	$0.00	$0	$0.29	$806	$0.30	$834	$1,640
Backfill Trench, 1 CY Bkt, Min Haul	669	CY	$0.00	$0	$0.74	$495	$0.58	$388	$883
Pipe Bedding, Side Slope 1/2:1	2,780	LF	$1.01	$2,808	$1.39	$3,864	$2.40	$6,672	$13,344
Compaction by Vibr. Plate	2,780	LF	$0.00	$0	$0.37	$1,029	$0.29	$806	$1,835
Subtotal, Excavation / Backfill / Compaction				**$2,808**		**$9,607**		**$9,132**	**$21,547**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
8" PVC Pipe, Schedule 80	2,780	LF	$8.45	$23,494	$4.15	$11,537	$0.68	$1,890	$36,921
Subtotal, PVC Pipe				**$23,494**		**$11,537**		**$1,890**	**$36,921**
Pipe Fittings: Couplings (PVC Fittings)									
8" PVC Coupling, Schedule 80	70	EA	$48.00	$3,360	$49.00	$3,430	$0.00	$0	$6,790
Subtotal: Pipe Fittings: Couplings				**$3,360**		**$3,430**		**$0**	**$6,790**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
8" PVC 45&90° Elbow, Schedule 80	1	EA	$62.00	$62	$86.00	$86	$0.00	$0	$148
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$62**		**$86**		**$0**	**$148**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	8	EA	$65.00	$520	$115.00	$920	$0.00	$0	$1,440
Subtotal: Pipe Fittings: TEE				**$520**		**$920**		**$0**	**$1,440**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	8	EA	$720	$5,760	$166	$1,328	$0.00	$0	$7,088
Subtotal: Shut-Off Valves				**$5,760**		**$1,328**		**$0**	**$7,088**
Pressure Regulating Valves (Installation, twice Means for Shut-Off Valve + Materials from Watts)									
8" Pressure Regulating Valve	5	EA	$2,683	$13,415	$332	$1,660	$0.00	$0	$15,075
Subtotal: Shut-Off Valves				**$13,415**		**$1,660**		**$0**	**$15,075**

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area A** - Inner Loop Road, Goldstone to 5th	Estimator: BIH	Checked By: RCL

Line Item	Quantity No. Units	Quantity Unit Meas.	Material Per Unit	Material Total	Labor Per Unit	Labor Total	Equipment Per Unit	Equipment Total	Total Cost
Hand Hole Vaults for PRV's									
Hand Hole for PRV > 6"	5	EA	$570	$2,850	$177	$885	$72.00	$360	$4,095
Subtotal: Hand Hole Vaults for PRV's				**$2,850**		**$885**		**$360**	**$4,095**
Fire Hydrants									
Fire Hydrant	5	EA	$785	$3,925	$67	$333	$10.85	$54	$4,312
Subtotal: Fire Hydrants				**$3,925**		**$333**		**$54**	**$4,312**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$5,339**	50.0%	**$10,089**	10.0%	**$230**	**$15,659**
Subtotal				$70,133		$59,492		$28,819	$158,445
California Sales Tax	7.75%	%		$5,435				$2,233	$7,669
Subtotal									$166,113
Contractor OH & Profit	25.0%	%							$41,528
Subtotal									$207,642
Bond	1.5%	%							$3,115
Subtotal									$210,756
Estimating Contingency	20.0%	%							$42,151
Total Probable Construction Cost									$252,908

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area B** - Avenue B, Industrial Area, Complete	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	2,155	LF	$0.03	$65	$0.54	$1,164	$0.00	$0	$1,228
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	22	EA	$0.00	$0	$25.00	$550	$31.40	$691	$1,241
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	2,586	LF	$0.38	$983	$1.38	$3,569	$1.06	$2,741	$7,293
Saw Cut Concrete (10-inch depth)	862	LF	$4.20	$3,620	$6.80	$5,862	$5.20	$4,482	$13,964
Pavement Removal, Bituminous to 6"	431	SY	$2.20	$948	$2.98	$1,284	$5.18	$2,233	$4,465
Concrete Removal, Rod Reinforced	144	SY	$4.61	$662	$6.25	$898	$10.86	$1,560	$3,120
Haul Pavements 12 CY Truck 10 mi RT	112	CY	$3.48	$389	$8.80	$983	$12.28	$1,372	$2,744
Subtotal, Survey, Site Investigation & Demolition				**$6,667**		**$15,477**		**$13,370**	**$35,514**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	130	CY	$0.00	$0	$11.55	$1,498	$0.00	$0	$1,498
Compaction by Roller, Walking	389	CY	$0.00	$0	$2.95	$1,148	$0.86	$335	$1,482
Trench: 40 HP, Riding, 16"W 36"D	2,155	LF	$0.00	$0	$0.29	$625	$0.30	$647	$1,271
Backfill Trench, 1 CY Bkt, Min Haul	519	CY	$0.00	$0	$0.74	$384	$0.58	$301	$685
Pipe Bedding, Side Slope 1/2:1	2,155	LF	$1.01	$2,177	$1.39	$2,995	$2.40	$5,172	$10,344
Compaction by Vibr. Plate	2,155	LF	$0.00	$0	$0.37	$797	$0.29	$625	$1,422
Subtotal, Excavation / Backfill / Compaction				**$2,177**		**$7,448**		**$7,079**	**$16,703**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
6" PVC Pipe, Schedule 80	470	LF	$5.46	$2,566	$3.07	$1,443	$0.00	$0	$4,009
8" PVC Pipe, Schedule 80	1,685	LF	$8.45	$14,240	$4.15	$6,993	$0.68	$1,146	$22,378
Subtotal, PVC Pipe				**$16,806**		**$8,436**		**$1,146**	**$26,388**
Pipe Fittings: Couplings (PVC Fittings)									
6" PVC Coupling, Schedule 80	12	EA	$23.00	$276	$37.00	$444	$0.00	$0	$720
8" PVC Coupling, Schedule 80	42	EA	$48.00	$2,016	$49.00	$2,058	$0.00	$0	$4,074
Subtotal: Pipe Fittings: Couplings				**$2,292**		**$2,502**		**$0**	**$4,794**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
6" PVC 45&90° Elbow, Schedule 80	1	EA	$27.50	$28	$63.00	$63	$0.00	$0	$91
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$28**		**$63**		**$0**	**$91**
Pipe Fittings: TEE (PVC Fittings)									
6" PVC Tee, Schedule 80	5	EA	$46.00	$230	$88.50	$443	$0.00	$0	$673
Subtotal: Pipe Fittings: TEE				**$230**		**$443**		**$0**	**$673**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
6" Shut Off Valve	8	EA	$400	$3,200	$111	$888	$0.00	$0	$4,088
8" Shut Off Valve	1	EA	$720	$720	$166	$166	$0.00	$0	$886
Subtotal: Shut-Off Valves				**$3,920**		**$1,054**		**$0**	**$4,974**

F:\PROJ\1640321\ENGR\Newpipe1 Domestic Area B

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2

Project	Project No.	Basis for Estimate
EEAP, FY 96 Fort Irwin, Water Conservation Study	PN 351	Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area B** - Avenue B, Industrial Area, Complete	Estimator: **BIH**	Checked By: **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Fire Hydrants									
Fire Hydrant	7	EA	$785	$5,495	$67	$466	$10.85	$76	$6,036
Subtotal: Fire Hydrants				**$5,495**		**$466**		**$76**	**$6,036**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$2,877**	50.0%	**$6,481**	10.0%	**$122**	**$9,481**
Subtotal				$40,491		$42,368		$21,793	$104,653
California Sales Tax	7.75%	%		$3,138				$1,689	$4,827
Subtotal									$109,480
Contractor OH & Profit	25.0%	%							$27,370
Subtotal									$136,850
Bond	1.5%	%							$2,053
Subtotal									$138,903
Estimating Contingency	20.0%	%							$27,781
Total Probable Construction Cost									$166,684

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2

Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area C** - Barstow Road - Langford to 7th	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	3,280	LF	$0.03	$98	$0.54	$1,771	$0.00	$0	$1,870
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	33	EA	$0.00	$0	$25.00	$825	$31.40	$1,036	$1,861
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	3,936	LF	$0.38	$1,496	$1.38	$5,432	$1.06	$4,172	$11,100
Saw Cut Concrete (10-inch depth)	1,312	LF	$4.20	$5,510	$6.80	$8,922	$5.20	$6,822	$21,254
Pavement Removal, Bituminous to 6"	656	SY	$2.20	$1,443	$2.98	$1,955	$5.18	$3,398	$6,796
Concrete Removal, Rod Reinforced	219	SY	$4.61	$1,008	$6.25	$1,367	$10.86	$2,375	$4,749
Haul Pavements 12 CY Truck 10 mi RT	170	CY	$3.48	$592	$8.80	$1,497	$12.28	$2,089	$4,177
Subtotal, Survey, Site Investigation & Demolition				**$10,148**		**$22,935**		**$20,183**	**$53,265**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	197	CY	$0.00	$0	$11.55	$2,280	$0.00	$0	$2,280
Compaction by Roller, Walking	592	CY	$0.00	$0	$2.95	$1,747	$0.86	$509	$2,256
Trench: 40 HP, Riding, 16"W 36"D	3,280	LF	$0.00	$0	$0.29	$951	$0.30	$984	$1,935
Backfill Trench, 1 CY Bkt, Min Haul	790	CY	$0.00	$0	$0.74	$584	$0.58	$458	$1,042
Pipe Bedding, Side Slope 1/2:1	3,280	LF	$1.01	$3,313	$1.39	$4,559	$2.40	$7,872	$15,744
Compaction by Vibr. Plate	3,280	LF	$0.00	$0	$0.37	$1,214	$0.29	$951	$2,165
Subtotal, Excavation / Backfill / Compaction				**$3,313**		**$11,335**		**$10,774**	**$25,423**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
6" PVC Pipe, Schedule 80	1,250	LF	$5.46	$6,825	$3.07	$3,838	$0.00	$0	$10,663
8" PVC Pipe, Schedule 80	2,030	LF	$8.45	$17,156	$4.15	$8,425	$0.68	$1,380	$26,960
Subtotal, PVC Pipe				**$23,981**		**$12,262**		**$1,380**	**$37,623**
Pipe Fittings: Couplings (PVC Fittings)									
6" PVC Coupling, Schedule 80	31	EA	$23.00	$713	$37.00	$1,147	$0.00	$0	$1,860
8" PVC Coupling, Schedule 80	51	EA	$48.00	$2,448	$49.00	$2,499	$0.00	$0	$4,947
Subtotal: Pipe Fittings: Couplings				**$3,161**		**$3,646**		**$0**	**$6,807**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
8" PVC 45&90° Elbow, Schedule 80	1	EA	$62.00	$62	$86.00	$86	$0.00	$0	$148
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$62**		**$86**		**$0**	**$148**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	14	EA	$65.00	$910	$115.00	$1,610	$0.00	$0	$2,520
Subtotal: Pipe Fittings: TEE				**$910**		**$1,610**		**$0**	**$2,520**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
6" Shut Off Valve	5	EA	$400	$2,000	$111	$555	$0.00	$0	$2,555
8" Shut Off Valve	5	EA	$720	$3,600	$166	$830	$0.00	$0	$4,430
Subtotal: Shut-Off Valves				**$5,600**		**$1,385**		**$0**	**$6,985**

F:\PROJ\1640321\ENGR\Newpipe1 Domestic Area C

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area C** - Barstow Road - Langford to 7th	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Pressure Regulating Valves (Installation, twice Means for Shut-Off Valve + Materials from Watts)									
6" Pressure Regulating Valve	2	EA	$1,599	$3,198	$222	$444	$0.00	$0	$3,642
8" Pressure Regulating Valve	2	EA	$2,683	$5,366	$332	$664	$0.00	$0	$6,030
10" Pressure Regulating Valve	2	EA	$3,821	$7,642	$380	$760	$0.00	$0	$8,402
Subtotal: Pressure Regulating Valves				**$16,206**		**$1,868**		**$0**	**$18,074**
Hand Hole Vaults for PRV's									
Hand Hole for PRV 1-6"	2	EA	$270	$540	$126	$252	$0.00	$0	$792
Hand Hole for PRV > 6"	4	EA	$570	$2,280	$177	$708	$72.00	$288	$3,276
Subtotal: Hand Hole Vaults for PRV's				**$2,820**		**$960**		**$288**	**$4,068**
Fire Hydrants									
Fire Hydrant	11	EA	$785	$8,635	$67	$732	$10.85	$119	$9,486
Subtotal: Fire Hydrants				**$8,635**		**$732**		**$119**	**$9,486**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$6,137**	50.0%	**$11,274**	10.0%	**$179**	**$17,591**
Subtotal				$80,972		$68,093		$32,924	$181,990
California Sales Tax	7.75%	%		$6,275				$2,552	$8,827
Subtotal									$190,817
Contractor OH & Profit	25.0%	%							$47,704
Subtotal									$238,521
Bond	1.5%	%							$3,578
Subtotal									$242,099
Estimating Contingency	20.0%	%							$48,420
Total Probable Construction Cost									$290,519

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area D** - 5th - 7th / Barstow - B	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	1,190	LF	$0.03	$36	$0.54	$643	$0.00	$0	$678
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	12	EA	$0.00	$0	$25.00	$300	$31.40	$377	$677
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	1,428	LF	$0.38	$543	$1.38	$1,971	$1.06	$1,514	$4,027
Saw Cut Concrete (10-inch depth)	476	LF	$4.20	$1,999	$6.80	$3,237	$5.20	$2,475	$7,711
Pavement Removal, Bituminous to 6"	238	SY	$2.20	$524	$2.98	$709	$5.18	$1,233	$2,466
Concrete Removal, Rod Reinforced	79	SY	$4.61	$366	$6.25	$496	$10.86	$862	$1,723
Haul Pavements 12 CY Truck 10 mi RT	62	CY	$3.48	$215	$8.80	$543	$12.28	$758	$1,515
Subtotal, Survey, Site Investigation & Demolition				**$3,682**		**$9,065**		**$7,509**	**$20,256**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	72	CY	$0.00	$0	$11.55	$827	$0.00	$0	$827
Compaction by Roller, Walking	215	CY	$0.00	$0	$2.95	$634	$0.86	$185	$819
Trench: 40 HP, Riding, 16"W 36"D	1,190	LF	$0.00	$0	$0.29	$345	$0.30	$357	$702
Backfill Trench, 1 CY Bkt, Min Haul	286	CY	$0.00	$0	$0.74	$212	$0.58	$166	$378
Pipe Bedding, Side Slope 1/2:1	1,190	LF	$1.01	$1,202	$1.39	$1,654	$2.40	$2,856	$5,712
Compaction by Vibr. Plate	1,190	LF	$0.00	$0	$0.37	$440	$0.29	$345	$785
Subtotal, Excavation / Backfill / Compaction				**$1,202**		**$4,113**		**$3,909**	**$9,223**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
2" PVC Pipe, Schedule 80	300	LF	$1.47	$442	$2.21	$663	$0.00	$0	$1,105
8" PVC Pipe, Schedule 80	890	LF	$8.45	$7,521	$4.15	$3,694	$0.68	$605	$11,820
Subtotal, PVC Pipe				**$7,963**		**$4,357**		**$605**	**$12,925**
Pipe Fittings: Couplings (PVC Fittings)									
2" PVC Coupling, Schedule 80	15	EA	$3.00	$45	$20.00	$300	$0.00	$0	$345
8" PVC Coupling, Schedule 80	22	EA	$48.00	$1,056	$49.00	$1,078	$0.00	$0	$2,134
Subtotal: Pipe Fittings: Couplings				**$1,101**		**$1,378**		**$0**	**$2,479**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
2" PVC 45&90° Elbow, Schedule 80	2	EA	$3.12	$6	$20.00	$40	$0.00	$0	$46
8" PVC 45&90° Elbow, Schedule 80	1	EA	$62.00	$62	$86.00	$86	$0.00	$0	$148
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$68**		**$126**		**$0**	**$194**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
2" Shut Off Valve	2	EA	$266	$531	$45	$91	$0.00	$0	$622
8" Shut Off Valve	2	EA	$720	$1,440	$166	$332	$0.00	$0	$1,772
Subtotal: Shut-Off Valves				**$1,971**		**$423**		**$0**	**$2,394**

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate **Code A (no design competed)**
Location Fort Irwin, California		
Engineer-Architect Keller & Gannon		
Drawing No. **Domestic Water Piping: Area D** - 5th - 7th / Barstow - B	Estimator **BIH**	Checked By **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Fire Hydrants									
Fire Hydrant	2	EA	$785	$1,570	$67	$133	$10.85	$22	$1,725
Subtotal: Fire Hydrants				**$1,570**		**$133**		**$22**	**$1,725**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$1,267**	50.0%	**$3,208**	10.0%	**$63**	**$4,539**
Subtotal				$18,825		$22,802		$12,107	$53,734
California Sales Tax	7.75%	%		$1,459				$938	$2,397
Subtotal									$56,132
Contractor OH & Profit	25.0%	%							$14,033
Subtotal									$70,164
Bond	1.5%	%							$1,052
Subtotal									$71,217
Estimating Contingency	20.0%	%							$14,243
Total Probable Construction Cost									$85,460

CONSTRUCTION COST ESTIMATE

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1	of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)	
Location: Fort Irwin, California			
Engineer-Architect: Keller & Gannon			
Drawing No.: **Domestic Water Piping: Area E** - 4th - 5th / Barstow to B		Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	3,290	LF	$0.03	$99	$0.54	$1,777	$0.00	$0	$1,875
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	33	EA	$0.00	$0	$25.00	$825	$31.40	$1,036	$1,861
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	3,948	LF	$0.38	$1,500	$1.38	$5,448	$1.06	$4,185	$11,133
Saw Cut Concrete (10-inch depth)	1,316	LF	$4.20	$5,527	$6.80	$8,949	$5.20	$6,843	$21,319
Pavement Removal, Bituminous to 6"	658	SY	$2.20	$1,448	$2.98	$1,961	$5.18	$3,408	$6,817
Concrete Removal, Rod Reinforced	219	SY	$4.61	$1,011	$6.25	$1,371	$10.86	$2,382	$4,764
Haul Pavements 12 CY Truck 10 mi RT	171	CY	$3.48	$594	$8.80	$1,501	$12.28	$2,095	$4,190
Subtotal, Survey, Site Investigation & Demolition				**$10,179**		**$22,999**		**$20,241**	**$53,418**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	198	CY	$0.00	$0	$11.55	$2,287	$0.00	$0	$2,287
Compaction by Roller, Walking	594	CY	$0.00	$0	$2.95	$1,752	$0.86	$511	$2,263
Trench: 40 HP, Riding, 16"W 36"D	3,290	LF	$0.00	$0	$0.29	$954	$0.30	$987	$1,941
Backfill Trench, 1 CY Bkt, Min Haul	792	CY	$0.00	$0	$0.74	$586	$0.58	$459	$1,045
Pipe Bedding, Side Slope 1/2:1	3,290	LF	$1.01	$3,323	$1.39	$4,573	$2.40	$7,896	$15,792
Compaction by Vibr. Plate	3,290	LF	$0.00	$0	$0.37	$1,217	$0.29	$954	$2,171
Subtotal, Excavation / Backfill / Compaction				**$3,323**		**$11,370**		**$10,807**	**$25,500**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
6" PVC Pipe, Schedule 80	910	LF	$5.46	$4,969	$3.07	$2,794	$0.00	$0	$7,762
8" PVC Pipe, Schedule 80	2,380	LF	$8.45	$20,113	$4.15	$9,877	$0.68	$1,618	$31,609
Subtotal, PVC Pipe				**$25,082**		**$12,671**		**$1,618**	**$39,371**
Pipe Fittings: Couplings (PVC Fittings)									
6" PVC Coupling, Schedule 80	23	EA	$23.00	$529	$37.00	$851	$0.00	$0	$1,380
8" PVC Coupling, Schedule 80	60	EA	$48.00	$2,880	$49.00	$2,940	$0.00	$0	$5,820
Subtotal: Pipe Fittings: Couplings				**$3,409**		**$3,791**		**$0**	**$7,200**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
8" PVC 45&90° Elbow, Schedule 80	4	EA	$62.00	$248	$86.00	$344	$0.00	$0	$592
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$248**		**$344**		**$0**	**$592**
Pipe Fittings: TEE (PVC Fittings)									
6" PVC Tee, Schedule 80	1	EA	$46.00	$46	$88.50	$89	$0.00	$0	$135
8" PVC Tee, Schedule 80	1	EA	$65.00	$65	$115.00	$115	$0.00	$0	$180
Subtotal: Pipe Fittings: TEE				**$111**		**$204**		**$0**	**$315**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	10	EA	$720	$7,200	$166	$1,660	$0.00	$0	$8,860
Subtotal: Shut-Off Valves				**$7,200**		**$1,660**		**$0**	**$8,860**

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2

Project	Project No.	Basis for Estimate
EEAP, FY 96 Fort Irwin, Water Conservation Study	PN 351	Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area E** - 4th - 5th / Barstow to B	Estimator: **BIH**	Checked By: **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Fire Hydrants									
Fire Hydrant	5	EA	$785	$3,925	$67	$333	$10.85	$54	$4,312
Subtotal: Fire Hydrants				**$3,925**		**$333**		**$54**	**$4,312**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$3,997**	50.0%	**$9,501**	10.0%	**$167**	**$13,666**
Subtotal				$57,474		$62,871		$32,888	$153,233
California Sales Tax	7.75%	%		$4,454				$2,549	$7,003
Subtotal									$160,236
Contractor OH & Profit	25.0%	%							$40,059
Subtotal									$200,296
Bond	1.5%	%							$3,004
Subtotal									$203,300
Estimating Contingency	20.0%	%							$40,660
Total Probable Construction Cost									$243,960

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area F** - 3rd-1st / Barstow to B	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	970	LF	$0.03	$29	$0.54	$524	$0.00	$0	$553
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	10	EA	$0.00	$0	$25.00	$250	$31.40	$314	$564
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	1,164	LF	$0.38	$442	$1.38	$1,606	$1.06	$1,234	$3,282
Saw Cut Concrete (10-inch depth)	388	LF	$4.20	$1,630	$6.80	$2,638	$5.20	$2,018	$6,286
Pavement Removal, Bituminous to 6"	194	SY	$2.20	$427	$2.98	$578	$5.18	$1,005	$2,010
Concrete Removal, Rod Reinforced	65	SY	$4.61	$298	$6.25	$404	$10.86	$702	$1,405
Haul Pavements 12 CY Truck 10 mi RT	50	CY	$3.48	$175	$8.80	$443	$12.28	$618	$1,235
Subtotal, Survey, Site Investigation & Demolition				**$3,001**		**$7,610**		**$6,181**	**$16,793**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	58	CY	$0.00	$0	$11.55	$674	$0.00	$0	$674
Compaction by Roller, Walking	175	CY	$0.00	$0	$2.95	$517	$0.86	$151	$667
Trench: 40 HP, Riding, 16"W 36"D	970	LF	$0.00	$0	$0.29	$281	$0.30	$291	$572
Backfill Trench, 1 CY Bkt, Min Haul	234	CY	$0.00	$0	$0.74	$173	$0.58	$135	$308
Pipe Bedding, Side Slope 1/2:1	970	LF	$1.01	$980	$1.39	$1,348	$2.40	$2,328	$4,656
Compaction by Vibr. Plate	970	LF	$0.00	$0	$0.37	$359	$0.29	$281	$640
Subtotal, Excavation / Backfill / Compaction				**$980**		**$3,352**		**$3,186**	**$7,518**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
10" PVC Pipe, Schedule 80	970	LF	$29.70	$28,809	$5.19	$5,034	$0.85	$825	$34,668
Subtotal, PVC Pipe				**$28,809**		**$5,034**		**$825**	**$34,668**
Pipe Fittings: Couplings (PVC Fittings)									
10" PVC Coupling, Schedule 80	24	EA	$55.00	$1,320	$53.00	$1,272	$0.00	$0	$2,592
Subtotal: Pipe Fittings: Couplings				**$1,320**		**$1,272**		**$0**	**$2,592**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
10" PVC 45&90° Elbow, Sch 80	1	EA	$89.50	$90	$149.00	$149	$0.00	$0	$239
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$90**		**$149**		**$0**	**$239**
Pipe Fittings: TEE (PVC Fittings)									
10" PVC Tee, Sch 80	1	EA	$111.00	$111	$203.50	$204	$0.00	$0	$315
Subtotal: Pipe Fittings: TEE				**$111**		**$204**		**$0**	**$315**
Pipe Fittings: Cross (PVC Fittings)									
10x10" PVC Cross, Sch 80	1	EA	$1,275	$1,275	$31.50	$32	$0.00	$0	$1,307
Subtotal: Pipe Fittings: Cross				**$1,275**		**$32**		**$0**	**$1,307**

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area F** - 3rd-1st / Barstow to B	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
10" Shut Off Valve	3	EA	$1,225	$3,675	$190	$570	$0.00	$0	$4,245
Subtotal: Shut-Off Valves				**$3,675**		**$570**		**$0**	**$4,245**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$3,528**	50.0%	**$3,630**	10.0%	**$82**	**$7,241**
Subtotal				$42,788		$21,853		$10,275	$74,916
California Sales Tax	7.75%	%		$3,316				$796	$4,112
Subtotal									$79,029
Contractor OH & Profit	25.0%	%							$19,757
Subtotal									$98,786
Bond	1.5%	%							$1,482
Subtotal									$100,268
Estimating Contingency	20.0%	%							$20,054
Total Probable Construction Cost									$120,321

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate Code A (no design competed)
Location Fort Irwin, California		
Engineer-Architect Keller & Gannon		
Drawing No. Domestic Water Piping: Area G - Langford-1st / Barstow - B	Estimator BIH	Checked By RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	2,320	LF	$0.03	$70	$0.54	$1,253	$0.00	$0	$1,322
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	23	EA	$0.00	$0	$25.00	$575	$31.40	$722	$1,297
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	2,784	LF	$0.38	$1,058	$1.38	$3,842	$1.06	$2,951	$7,851
Saw Cut Concrete (10-inch depth)	928	LF	$4.20	$3,898	$6.80	$6,310	$5.20	$4,826	$15,034
Pavement Removal, Bituminous to 6"	464	SY	$2.20	$1,021	$2.98	$1,383	$5.18	$2,404	$4,807
Concrete Removal, Rod Reinforced	155	SY	$4.61	$713	$6.25	$967	$10.86	$1,680	$3,359
Haul Pavements 12 CY Truck 10 mi RT	120	CY	$3.48	$419	$8.80	$1,059	$12.28	$1,477	$2,954
Subtotal, Survey, Site Investigation & Demolition				**$7,178**		**$16,555**		**$14,350**	**$38,083**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	140	CY	$0.00	$0	$11.55	$1,613	$0.00	$0	$1,613
Compaction by Roller, Walking	419	CY	$0.00	$0	$2.95	$1,236	$0.86	$360	$1,596
Trench: 40 HP, Riding, 16"W 36"D	2,320	LF	$0.00	$0	$0.29	$673	$0.30	$696	$1,369
Backfill Trench, 1 CY Bkt, Min Haul	559	CY	$0.00	$0	$0.74	$413	$0.58	$324	$737
Pipe Bedding, Side Slope 1/2:1	2,320	LF	$1.01	$2,343	$1.39	$3,225	$2.40	$5,568	$11,136
Compaction by Vibr. Plate	2,320	LF	$0.00	$0	$0.37	$858	$0.29	$673	$1,531
Subtotal, Excavation / Backfill / Compaction				**$2,343**		**$8,018**		**$7,621**	**$17,982**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
6" PVC Pipe, Schedule 80	930	LF	$5.46	$5,078	$3.07	$2,855	$0.00	$0	$7,933
8" PVC Pipe, Schedule 80	1,390	LF	$8.45	$11,747	$4.15	$5,769	$0.68	$945	$18,461
Subtotal, PVC Pipe				**$16,825**		**$8,624**		**$945**	**$26,393**
Pipe Fittings: Couplings (PVC Fittings)									
6" PVC Coupling, Schedule 80	23	EA	$23.00	$529	$37.00	$851	$0.00	$0	$1,380
8" PVC Coupling, Schedule 80	35	EA	$48.00	$1,680	$49.00	$1,715	$0.00	$0	$3,395
Subtotal: Pipe Fittings: Couplings				**$2,209**		**$2,566**		**$0**	**$4,775**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
8" PVC 45&90° Elbow, Schedule 80	1	EA	$62.00	$62	$86.00	$86	$0.00	$0	$148
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$62**		**$86**		**$0**	**$148**
Pipe Fittings: TEE (PVC Fittings)									
6" PVC Tee, Schedule 80	1	EA	$46.00	$46	$88.50	$89	$0.00	$0	$135
Subtotal: Pipe Fittings: TEE				**$46**		**$89**		**$0**	**$135**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
6" Shut Off Valve	2	EA	$400	$800	$111	$222	$0.00	$0	$1,022
8" Shut Off Valve	7	EA	$720	$5,040	$166	$1,162	$0.00	$0	$6,202
Subtotal: Shut-Off Valves				**$5,840**		**$1,384**		**$0**	**$7,224**
Pressure Regulating Valves (Installation, twice Means for Shut-Off Valve + Materials from Watts)									
8" Pressure Regulating Valve	1	EA	$2,683	$2,683	$332	$332	$0.00	$0	$3,015

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area G** - Langford-1st / Barstow - B	Estimator: **BIH**	Checked By: **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Subtotal: Pressure Regulating Valves				**$2,683**		**$332**		**$0**	**$3,015**
Hand Hole Vaults for PRV's									
Hand Hole for PRV > 6"	1	EA	$570	$570	$177	$177	$72.00	$72	$819
Subtotal: Hand Hole Vaults for PRV's				**$570**		**$177**		**$72**	**$819**
Fire Hydrants									
Fire Hydrant	2	EA	$785	$1,570	$67	$133	$10.85	$22	$1,725
Subtotal: Fire Hydrants				**$1,570**		**$133**		**$22**	**$1,725**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$2,980**	50.0%	**$6,695**	10.0%	**$104**	**$9,780**
Subtotal				$42,306		$44,658		$23,114	$110,079
California Sales Tax	7.75%	%		$3,279				$1,791	$5,070
Subtotal									$115,149
Contractor OH & Profit	25.0%	%							$28,787
Subtotal									$143,936
Bond	1.5%	%							$2,159
Subtotal									$146,095
Estimating Contingency	20.0%	%							$29,219
Total Probable Construction Cost									$175,314

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area H** - 1 Million Gal UST Lines from B	Estimator: BIH	Checked By: RCL

Line Item	Quantity No. Units	Quantity Unit Meas.	Material Per Unit	Material Total	Labor Per Unit	Labor Total	Equipment Per Unit	Equipment Total	Total Cost
Site Survey, Investigation & Demolition									
Survey, Pipeline	3,950	LF	$0.03	$119	$0.54	$2,133	$0.00	$0	$2,252
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	40	EA	$0.00	$0	$25.00	$1,000	$31.40	$1,256	$2,256
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	4,740	LF	$0.38	$1,801	$1.38	$6,541	$1.06	$5,024	$13,367
Saw Cut Concrete (10-inch depth)	1,580	LF	$4.20	$6,636	$6.80	$10,744	$5.20	$8,216	$25,596
Pavement Removal, Bituminous to 6"	790	SY	$2.20	$1,738	$2.98	$2,354	$5.18	$4,092	$8,184
Concrete Removal, Rod Reinforced	263	SY	$4.61	$1,214	$6.25	$1,646	$10.86	$2,860	$5,720
Haul Pavements 12 CY Truck 10 mi RT	205	CY	$3.48	$713	$8.80	$1,802	$12.28	$2,515	$5,030
Subtotal, Survey, Site Investigation & Demolition				**$12,220**		**$27,388**		**$24,255**	**$63,863**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	238	CY	$0.00	$0	$11.55	$2,746	$0.00	$0	$2,746
Compaction by Roller, Walking	713	CY	$0.00	$0	$2.95	$2,104	$0.86	$613	$2,717
Trench: 40 HP, Riding, 16"W 36"D	3,950	LF	$0.00	$0	$0.29	$1,146	$0.30	$1,185	$2,331
Backfill Trench, 1 CY Bkt, Min Haul	951	CY	$0.00	$0	$0.74	$704	$0.58	$552	$1,255
Pipe Bedding, Side Slope 1/2:1	3,950	LF	$1.01	$3,990	$1.39	$5,491	$2.40	$9,480	$18,960
Compaction by Vibr. Plate	3,950	LF	$0.00	$0	$0.37	$1,462	$0.29	$1,146	$2,607
Subtotal, Excavation / Backfill / Compaction				**$3,990**		**$13,651**		**$12,975**	**$30,616**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
8" PVC Pipe, Schedule 80	2,150	LF	$8.45	$18,170	$4.15	$8,923	$0.68	$1,462	$28,554
10" PVC Pipe, Schedule 80	940	LF	$29.70	$27,918	$5.19	$4,876	$0.85	$799	$33,593
12" PVC Pipe, Schedule 80	860	LF	$39.15	$33,669	$6.23	$5,354	$1.02	$877	$39,900
Subtotal, PVC Pipe				**$79,757**		**$19,152**		**$3,138**	**$102,047**
Pipe Fittings: Couplings (PVC Fittings)									
8" PVC Coupling, Schedule 80	54	EA	$48.00	$2,592	$49.00	$2,646	$0.00	$0	$5,238
10" PVC Coupling, Schedule 80	24	EA	$55.00	$1,320	$53.00	$1,272	$0.00	$0	$2,592
12" PVC Coupling, Schedule 80	22	EA	$63.00	$1,386	$57.50	$1,265	$0.00	$0	$2,651
Subtotal: Pipe Fittings: Couplings				**$5,298**		**$5,183**		**$0**	**$10,481**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
10" PVC 45&90° Elbow, Sch 80	7	EA	$89.50	$627	$149.00	$1,043	$0.00	$0	$1,670
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$627**		**$1,043**		**$0**	**$1,670**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	1	EA	$65.00	$65	$115.00	$115	$0.00	$0	$180
Subtotal: Pipe Fittings: TEE				**$65**		**$115**		**$0**	**$180**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	2	EA	$720	$1,440	$166	$332	$0.00	$0	$1,772
10" Shut Off Valve	3	EA	$1,225	$3,675	$190	$570	$0.00	$0	$4,245
12" Shut Off Valve	2	EA	$1,725	$3,450	$221	$442	$0.00	$0	$3,892
Subtotal: Shut-Off Valves				**$8,565**		**$1,344**		**$0**	**$9,909**

CONSTRUCTION COST ESTIMATE					Date Prepared: Mar. '97 (Rev. April '97)			Sheet 2 of 2		
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study					Project No.: PN 351	Basis for Estimate: Code A (no design competed)				
Location: Fort Irwin, California										
Engineer-Architect: Keller & Gannon										
Drawing No.: **Domestic Water Piping: Area H** - 1 Million Gal UST Lines from B						Estimator: BIH		Checked By: RCL		

Line Item	Quantity No. Units	Quantity Unit Meas.	Material Per Unit	Material Total	Labor Per Unit	Labor Total	Equipment Per Unit	Equipment Total	Total Cost
Fire Hydrants									
Fire Hydrant	3	EA	$785	$2,355	$67	$200	$10.85	$33	$2,587
Subtotal: Fire Hydrants				**$2,355**		**$200**		**$33**	**$2,587**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$9,667**	50.0%	**$13,518**	10.0%	**$317**	**$23,503**
Subtotal				$122,543		$81,594		$40,718	$244,855
California Sales Tax	7.75%	%		$9,497				$3,156	$12,653
Subtotal									$257,507
Contractor OH & Profit	25.0%	%							$64,377
Subtotal									$321,884
Bond	1.5%	%							$4,828
Subtotal									$326,712
Estimating Contingency	20.0%	%							$65,342
Total Probable Construction Cost									$392,055

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. 97 (Rev. April '97)	Sheet 1 of 2	
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)	
Location: Fort Irwin, California			
Engineer-Architect: Keller & Gannon			
Drawing No.: **Domestic Water Piping: Area I** - Inner Loop - Ave B / 5th - Goldstone		Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	3,060	LF	$0.03	$92	$0.54	$1,652	$0.00	$0	$1,744
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	31	EA	$0.00	$0	$25.00	$775	$31.40	$973	$1,748
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	3,672	LF	$0.38	$1,395	$1.38	$5,067	$1.06	$3,892	$10,355
Saw Cut Concrete (10-inch depth)	1,224	LF	$4.20	$5,141	$6.80	$8,323	$5.20	$6,365	$19,829
Pavement Removal, Bituminous to 6"	612	SY	$2.20	$1,346	$2.98	$1,824	$5.18	$3,170	$6,340
Concrete Removal, Rod Reinforced	204	SY	$4.61	$940	$6.25	$1,275	$10.86	$2,215	$4,431
Haul Pavements 12 CY Truck 10 mi RT	159	CY	$3.48	$552	$8.80	$1,396	$12.28	$1,948	$3,897
Subtotal, Survey, Site Investigation & Demolition				**$9,467**		**$21,480**		**$18,856**	**$49,802**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	184	CY	$0.00	$0	$11.55	$2,127	$0.00	$0	$2,127
Compaction by Roller, Walking	553	CY	$0.00	$0	$2.95	$1,630	$0.86	$475	$2,105
Trench: 40 HP, Riding, 16"W 36"D	3,060	LF	$0.00	$0	$0.29	$887	$0.30	$918	$1,805
Backfill Trench, 1 CY Bkt, Min Haul	737	CY	$0.00	$0	$0.74	$545	$0.58	$427	$972
Pipe Bedding, Side Slope 1/2:1	3,060	LF	$1.01	$3,091	$1.39	$4,253	$2.40	$7,344	$14,688
Compaction by Vibr. Plate	3,060	LF	$0.00	$0	$0.37	$1,132	$0.29	$887	$2,020
Subtotal, Excavation / Backfill / Compaction				**$3,091**		**$10,575**		**$10,052**	**$23,718**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
6" PVC Pipe, Schedule 80	710	LF	$5.46	$3,877	$3.07	$2,180	$0.00	$0	$6,056
8" PVC Pipe, Schedule 80	2,350	LF	$8.45	$19,860	$4.15	$9,753	$0.68	$1,598	$31,210
Subtotal, PVC Pipe				**$23,736**		**$11,932**		**$1,598**	**$37,267**
Pipe Fittings: Couplings (PVC Fittings)									
6" PVC Coupling, Schedule 80	18	EA	$23.00	$414	$37.00	$666	$0.00	$0	$1,080
8" PVC Coupling, Schedule 80	59	EA	$48.00	$2,832	$49.00	$2,891	$0.00	$0	$5,723
Subtotal: Pipe Fittings: Couplings				**$3,246**		**$3,557**		**$0**	**$6,803**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	3	EA	$65.00	$195	$115.00	$345	$0.00	$0	$540
Subtotal: Pipe Fittings: TEE				**$195**		**$345**		**$0**	**$540**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
6" Shut Off Valve	2	EA	$400	$800	$111	$222	$0.00	$0	$1,022
8" Shut Off Valve	4	EA	$720	$2,880	$166	$664	$0.00	$0	$3,544
Subtotal: Shut-Off Valves				**$3,680**		**$886**		**$0**	**$4,566**
Pressure Regulating Valves (Installation, twice Means for Shut-Off Valve + Materials from Watts)									
8" Pressure Regulating Valve	1	EA	$2,683	$2,683	$332	$332	$0.00	$0	$3,015
Subtotal: Pressure Regulating Valves				**$2,683**		**$332**		**$0**	**$3,015**

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. 97 (Rev. April '97)	Sheet 2 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area I** - Inner Loop - Ave B / 5th - Goldstone	Estimator: BIH	Checked By: RCL

Line Item	Quantity No. Units	Quantity Unit Meas.	Material Per Unit	Material Total	Labor Per Unit	Labor Total	Equipment Per Unit	Equipment Total	Total Cost
Hand Hole Vaults for PRV's									
Hand Hole for PRV > 6"	1	EA	$570	$570	$177	$177	$72.00	$72	$819
Subtotal: Hand Hole Vaults for PRV's				**$570**		**$177**		**$72**	**$819**
Fire Hydrants									
Fire Hydrant	2	EA	$785	$1,570	$67	$133	$10.85	$22	$1,725
Subtotal: Fire Hydrants				**$1,570**		**$133**		**$22**	**$1,725**
Service Taps (Allow 1 per building)									
Drill & Tap 6" Main, 1"-2" Service	1	EA	$0	$0	$147	$147	$0.00	$0	$147
Drill & Tap 8" Main, 1"-2" Service	5	EA	$0	$0	$161	$805	$0.00	$0	$805
2" Shut Off Valve w/ Street Box	5	EA	$266	$1,328	$45	$226	$0.00	$0	$1,554
Subtotal: Service Taps				**$1,328**		**$1,178**		**$0**	**$2,506**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$3,701**	50.0%	**$9,270**	10.0%	**$169**	**$13,141**
Subtotal				$53,267		$59,866		$30,768	$143,902
California Sales Tax	7.75%	%		$4,128				$2,385	$6,513
Subtotal									$150,415
Contractor OH & Profit	25.0%	%							$37,604
Subtotal									$188,018
Bond	1.5%	%							$2,820
Subtotal									$190,838
Estimating Contingency	20.0%	%							$38,168
Total Probable Construction Cost									$229,006

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April 1997)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area M** - Barstow-7th / Sanitary-F	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	2,330	LF	$0.03	$70	$0.54	$1,258	$0.00	$0	$1,328
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	23	EA	$0.00	$0	$25.00	$575	$31.40	$722	$1,297
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	2,796	LF	$0.38	$1,062	$1.38	$3,858	$1.06	$2,964	$7,885
Saw Cut Concrete (10-inch depth)	932	LF	$4.20	$3,914	$6.80	$6,338	$5.20	$4,846	$15,098
Pavement Removal, Bituminous to 6"	466	SY	$2.20	$1,025	$2.98	$1,389	$5.18	$2,414	$4,828
Concrete Removal, Rod Reinforced	155	SY	$4.61	$716	$6.25	$971	$10.86	$1,687	$3,374
Haul Pavements 12 CY Truck 10 mi RT	121	CY	$3.48	$420	$8.80	$1,063	$12.28	$1,484	$2,967
Subtotal, Survey, Site Investigation & Demolition				**$7,209**		**$16,619**		**$14,408**	**$38,235**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	140	CY	$0.00	$0	$11.55	$1,620	$0.00	$0	$1,620
Compaction by Roller, Walking	421	CY	$0.00	$0	$2.95	$1,241	$0.86	$362	$1,603
Trench: 40 HP, Riding, 16"W 36"D	2,330	LF	$0.00	$0	$0.29	$676	$0.30	$699	$1,375
Backfill Trench, 1 CY Bkt, Min Haul	561	CY	$0.00	$0	$0.74	$415	$0.58	$325	$740
Pipe Bedding, Side Slope 1/2:1	2,330	LF	$1.01	$2,353	$1.39	$3,239	$2.40	$5,592	$11,184
Compaction by Vibr. Plate	2,330	LF	$0.00	$0	$0.37	$862	$0.29	$676	$1,538
Subtotal, Excavation / Backfill / Compaction				**$2,353**		**$8,052**		**$7,654**	**$18,059**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
2" PVC Pipe, Schedule 80	200	LF	$1.47	$295	$2.21	$442	$0.00	$0	$737
6" PVC Pipe, Schedule 80	875	LF	$5.46	$4,778	$3.07	$2,686	$0.00	$0	$7,464
10" PVC Pipe, Schedule 80	1,255	LF	$29.70	$37,274	$5.19	$6,513	$0.85	$1,067	$44,854
Subtotal, PVC Pipe				**$42,346**		**$9,642**		**$1,067**	**$53,054**
Pipe Fittings: Couplings (PVC Fittings)									
2" PVC Coupling, Schedule 80	10	EA	$3.00	$30	$20.00	$200	$0.00	$0	$230
6" PVC Coupling, Schedule 80	22	EA	$23.00	$506	$37.00	$814	$0.00	$0	$1,320
10" PVC Coupling, Schedule 80	31	EA	$55.00	$1,705	$53.00	$1,643	$0.00	$0	$3,348
Subtotal: Pipe Fittings: Couplings				**$2,241**		**$2,657**		**$0**	**$4,898**
Pipe Fittings: TEE (PVC Fittings)									
10" PVC Tee, Sch 80	2	EA	$111.00	$222	$203.50	$407	$0.00	$0	$629
Subtotal: Pipe Fittings: TEE				**$222**		**$407**		**$0**	**$629**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
6" Shut Off Valve	3	EA	$400	$1,200	$111	$333	$0.00	$0	$1,533
10" Shut Off Valve	6	EA	$1,225	$7,350	$190	$1,140	$0.00	$0	$8,490
Subtotal: Shut-Off Valves				**$8,550**		**$1,473**		**$0**	**$10,023**
Fire Hydrants									
Fire Hydrant	3	EA	$785	$2,355	$67	$200	$10.85	$33	$2,587
Subtotal: Fire Hydrants				**$2,355**		**$200**		**$33**	**$2,587**

F:\PROJ\1640321\ENGR\Newpipe1 Domestic Area M

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April 1997)	Sheet 2	of 2

Project EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate Code A (no design competed)
Location Fort Irwin, California		
Engineer-Architect Keller & Gannon		
Drawing No. **Domestic Water Piping: Area M** - Barstow-7th / Sanitary-F	Estimator **BIH**	Checked By **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Service Taps (Allow 1 per building)									
Drill & Tap 6" Main, 1"-2" Service	1	EA	$0	$0	$147	$147	$0.00	$0	$147
Drill & Tap 8" Main, 1"-2" Service	5	EA	$0	$0	$161	$805	$0.00	$0	$805
1" Shut Off Valve w/ Street Box	1	EA	$266	$266	$45	$45	$0.00	$0	$311
2" Shut Off Valve w/ Street Box	5	EA	$266	$1,328	$45	$226	$0.00	$0	$1,554
Subtotal: Service Taps				**$1,594**		**$1,224**		**$0**	**$2,817**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$5,731**	50.0%	**$7,801**	10.0%	**$110**	**$13,642**
Subtotal				$72,600		$48,074		$23,271	$143,945
California Sales Tax	7.75%	%		$5,626				$1,803	$7,430
Subtotal									$151,375
Contractor OH & Profit	25.0%	%							$37,844
Subtotal									$189,219
Bond	1.5%	%							$2,838
Subtotal									$192,057
Estimating Contingency	20.0%	%							$38,411
Total Probable Construction Cost									$230,469

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area N** - 2nd - 5th / Barstow - F	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	5,755	LF	$0.03	$173	$0.54	$3,108	$0.00	$0	$3,280
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	58	EA	$0.00	$0	$25.00	$1,450	$31.40	$1,821	$3,271
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	6,906	LF	$0.38	$2,624	$1.38	$9,530	$1.06	$7,320	$19,475
Saw Cut Concrete (10-inch depth)	2,302	LF	$4.20	$9,668	$6.80	$15,654	$5.20	$11,970	$37,292
Pavement Removal, Bituminous to 6"	1,151	SY	$2.20	$2,532	$2.98	$3,430	$5.18	$5,962	$11,924
Concrete Removal, Rod Reinforced	384	SY	$4.61	$1,769	$6.25	$2,398	$10.86	$4,167	$8,333
Haul Debris 12 CY Truck 10 mi RT	298	CY	$3.48	$1,038	$8.80	$2,626	$12.28	$3,664	$7,329
Subtotal, Survey, Site Investigation & Demolition				**$17,805**		**$39,362**		**$35,196**	**$92,363**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	346	CY	$0.00	$0	$11.55	$4,001	$0.00	$0	$4,001
Compaction by Roller, Walking	1,039	CY	$0.00	$0	$2.95	$3,065	$0.86	$894	$3,959
Trench: 40 HP, Riding, 16"W 36"D	5,755	LF	$0.00	$0	$0.29	$1,669	$0.30	$1,727	$3,395
Backfill Trench, 1 CY Bkt, Min Haul	1,385	CY	$0.00	$0	$0.74	$1,025	$0.58	$804	$1,829
Pipe Bedding, Side Slope 1/2:1	5,755	LF	$1.01	$5,813	$1.39	$7,999	$2.40	$13,812	$27,624
Compaction by Vibr. Plate	5,755	LF	$0.00	$0	$0.37	$2,129	$0.29	$1,669	$3,798
Subtotal, Excavation / Backfill / Compaction				**$5,813**		**$19,889**		**$18,905**	**$44,606**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
8" PVC Pipe, Schedule 80	3,670	LF	$8.45	$31,015	$4.15	$15,231	$0.68	$2,496	$48,741
10" PVC Pipe, Schedule 80	2,085	LF	$29.70	$61,925	$5.19	$10,821	$0.85	$1,772	$74,518
Subtotal, PVC Pipe				**$92,940**		**$26,052**		**$4,268**	**$123,259**
Pipe Fittings: Couplings (PVC Fittings)									
8" PVC Coupling, Schedule 80	92	EA	$48.00	$4,416	$49.00	$4,508	$0.00	$0	$8,924
10" PVC Coupling, Schedule 80	52	EA	$55.00	$2,860	$53.00	$2,756	$0.00	$0	$5,616
Subtotal: Pipe Fittings: Couplings				**$7,276**		**$7,264**		**$0**	**$14,540**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
10" PVC 45&90° Elbow, Sch 80	2	EA	$89.50	$179	$149.00	$298	$0.00	$0	$477
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$179**		**$298**		**$0**	**$477**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	3	EA	$65.00	$195	$115.00	$345	$0.00	$0	$540
10" PVC Tee, Sch 80	1	EA	$111.00	$111	$203.50	$204	$0.00	$0	$315
Subtotal: Pipe Fittings: TEE				**$306**		**$549**		**$0**	**$855**
Pipe Fittings: Cross (PVC Fittings)									
8x8" PVC Cross, Schedule 80	1	EA	$640	$640	$31.50	$32	$0.00	$0	$672
10x6" PVC Cross, Sch 80	1	EA	$1,175	$1,175	$31.50	$32	$0.00	$0	$1,207
Subtotal: Pipe Fittings: Cross				**$1,815**		**$63**		**$0**	**$1,878**

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2

Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351
Location: Fort Irwin, California	Basis for Estimate: Code A (no design competed)
Engineer-Architect: Keller & Gannon	
Drawing No.: **Domestic Water Piping: Area N** - 2nd - 5th / Barstow - F	Estimator: BIH; Checked By: RCL

Line Item	Quantity No. Units	Quantity Unit Meas.	Material Per Unit	Material Total	Labor Per Unit	Labor Total	Equipment Per Unit	Equipment Total	Total Cost
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	15	EA	$720	$10,800	$166	$2,490	$0.00	$0	$13,290
10" Shut Off Valve	6	EA	$1,225	$7,350	$190	$1,140	$0.00	$0	$8,490
Subtotal: Shut-Off Valves				**$18,150**		**$3,630**		**$0**	**$21,780**
Pressure Regulating Valves (Installation, twice Means for Shut-Off Valve + Materials from Watts)									
10" Pressure Regulating Valve	1	EA	$3,821	$3,821	$380	$380	$0.00	$0	$4,201
Subtotal: Pressure Regulating Valves				**$3,821**		**$380**		**$0**	**$4,201**
Hand Hole Vaults for PRV's									
Hand Hole for PRV > 6"	1	EA	$570	$570	$177	$177	$72.00	$72	$819
Subtotal: Hand Hole Vaults for PRV's				**$570**		**$177**		**$72**	**$819**
Fire Hydrants									
Fire Hydrant	10	EA	$785	$7,850	$67	$665	$10.85	$109	$8,624
Subtotal: Fire Hydrants				**$7,850**		**$665**		**$109**	**$8,624**
Service Taps (Allow 1 per building)									
Drill & Tap 6" Main, 1"-2" Service	1	EA	$0	$0	$147	$147	$0.00	$0	$147
Drill & Tap 8" Main, 1"-2" Service	2	EA	$0	$0	$161	$322	$0.00	$0	$322
2" Shut Off Valve w/ Street Box	2	EA	$266	$531	$45	$91	$0.00	$0	$622
Subtotal: Service Taps				**$531**		**$560**		**$0**	**$1,091**
Mechanical Subcontractors Overhead & Profit			10.0%	**$13,344**	50.0%	**$19,818**	10.0%	**$445**	**$33,608**
Subtotal				$170,399		$118,706		$58,994	$348,100
California Sales Tax	7.75%	%		$13,206				$4,572	$17,778
Subtotal									$365,878
Contractor OH & Profit	25.0%	%							$91,469
Subtotal									$457,347
Bond	1.5%	%							$6,860
Subtotal									$464,208
Estimating Contingency	20.0%	%							$92,842
Total Probable Construction Cost									$557,049

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. 97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area O** - Barstow-Langford / 2nd-F	Estimator: **BIH**	Checked By: **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	925	LF	$0.03	$28	$0.54	$500	$0.00	$0	$527
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	9	EA	$0.00	$0	$25.00	$225	$31.40	$283	$508
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	1,110	LF	$0.38	$422	$1.38	$1,532	$1.06	$1,177	$3,130
Saw Cut Concrete (10-inch depth)	370	LF	$4.20	$1,554	$6.80	$2,516	$5.20	$1,924	$5,994
Pavement Removal, Bituminous to 6"	185	SY	$2.20	$407	$2.98	$551	$5.18	$958	$1,917
Concrete Removal, Rod Reinforced	62	SY	$4.61	$284	$6.25	$385	$10.86	$670	$1,339
Haul Pavements 12 CY Truck 10 mi RT	48	CY	$3.48	$167	$8.80	$422	$12.28	$589	$1,178
Subtotal, Survey, Site Investigation & Demolition				**$2,862**		**$7,298**		**$5,891**	**$16,051**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	56	CY	$0.00	$0	$11.55	$643	$0.00	$0	$643
Compaction by Roller, Walking	167	CY	$0.00	$0	$2.95	$493	$0.86	$144	$636
Trench: 40 HP, Riding, 16"W 36"D	925	LF	$0.00	$0	$0.29	$268	$0.30	$278	$546
Backfill Trench, 1 CY Bkt, Min Haul	223	CY	$0.00	$0	$0.74	$165	$0.58	$129	$294
Pipe Bedding, Side Slope 1/2:1	925	LF	$1.01	$934	$1.39	$1,286	$2.40	$2,220	$4,440
Compaction by Vibr. Plate	925	LF	$0.00	$0	$0.37	$342	$0.29	$268	$611
Subtotal, Excavation / Backfill / Compaction				**$934**		**$3,197**		**$3,039**	**$7,170**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
8" PVC Pipe, Schedule 80	925	LF	$8.45	$7,817	$4.15	$3,839	$0.68	$629	$12,285
Subtotal, PVC Pipe				**$7,817**		**$3,839**		**$629**	**$12,285**
Pipe Fittings: Couplings (PVC Fittings)									
8" PVC Coupling, Schedule 80	23	EA	$48.00	$1,104	$49.00	$1,127	$0.00	$0	$2,231
Subtotal: Pipe Fittings: Couplings				**$1,104**		**$1,127**		**$0**	**$2,231**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	1	EA	$65.00	$65	$115.00	$115	$0.00	$0	$180
Subtotal: Pipe Fittings: TEE				**$65**		**$115**		**$0**	**$180**
8" Shut Off Valve	2	EA	$720	$1,440	$166	$332	$0.00	$0	$1,772
Subtotal: Shut-Off Valves				**$1,440**		**$332**		**$0**	**$1,772**

CONSTRUCTION COST ESTIMATE

Date Prepared: Mar. 97 (Rev. April '97)	**Sheet** 2 **of** 2		
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	**Project No.:** PN 351	**Basis for Estimate:** Code A (no design competed)	
Location: Fort Irwin, California			
Engineer-Architect: Keller & Gannon			
Drawing No.: Domestic Water Piping: Area O - Barstow-Langford / 2nd-F		**Estimator:** BIH	**Checked By:** RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Fire Hydrants									
Fire Hydrant	2	EA	$785	$1,570	$67	$133	$10.85	$22	$1,725
Subtotal: Fire Hydrants				**$1,570**		**$133**		**$22**	**$1,725**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$1,200**	50.0%	**$2,773**	10.0%	**$65**	**$4,038**
Subtotal				$16,992		$18,813		$9,645	$45,451
California Sales Tax	7.75%	%		$1,317				$748	$2,064
Subtotal									$47,516
Contractor OH & Profit	25.0%	%							$11,879
Subtotal									$59,395
Bond	1.5%	%							$891
Subtotal									$60,286
Estimating Contingency	20.0%	%							$12,057
Total Probable Construction Cost									$72,343

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area P - Depot Loop & Road off Langford Rd**	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	5,300	LF	$0.03	$159	$0.54	$2,862	$0.00	$0	$3,021
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	53	EA	$0.00	$0	$25.00	$1,325	$31.40	$1,664	$2,989
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	6,360	LF	$0.38	$2,417	$1.38	$8,777	$1.06	$6,742	$17,935
Saw Cut Concrete (10-inch depth)	2,120	LF	$4.20	$8,904	$6.80	$14,416	$5.20	$11,024	$34,344
Pavement Removal, Bituminous to 6"	1,060	SY	$2.20	$2,332	$2.98	$3,159	$5.18	$5,491	$10,982
Concrete Removal, Rod Reinforced	353	SY	$4.61	$1,629	$6.25	$2,208	$10.86	$3,837	$7,674
Haul Pavements 12 CY Truck 10 mi RT	275	CY	$3.48	$956	$8.80	$2,418	$12.28	$3,375	$6,749
Subtotal, Survey, Site Investigation & Demolition				**$16,397**		**$36,332**		**$32,424**	**$85,153**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	319	CY	$0.00	$0	$11.55	$3,684	$0.00	$0	$3,684
Compaction by Roller, Walking	957	CY	$0.00	$0	$2.95	$2,823	$0.86	$823	$3,646
Trench: 40 HP, Riding, 16"W 36"D	5,300	LF	$0.00	$0	$0.29	$1,537	$0.30	$1,590	$3,127
Backfill Trench, 1 CY Bkt, Min Haul	1,276	CY	$0.00	$0	$0.74	$944	$0.58	$740	$1,684
Pipe Bedding, Side Slope 1/2:1	5,300	LF	$1.01	$5,353	$1.39	$7,367	$2.40	$12,720	$25,440
Compaction by Vibr. Plate	5,300	LF	$0.00	$0	$0.37	$1,961	$0.29	$1,537	$3,498
Subtotal, Excavation / Backfill / Compaction				**$5,353**		**$18,316**		**$17,410**	**$41,079**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
1-1/2" PVC Pipe, Schedule 80	120	LF	$1.30	$156	$1.84	$221	$0.00	$0	$377
6" PVC Pipe, Schedule 80	80	LF	$5.46	$437	$3.07	$246	$0.00	$0	$682
8" PVC Pipe, Schedule 80	5,100	LF	$8.45	$43,100	$4.15	$21,165	$0.68	$3,468	$67,733
Subtotal, PVC Pipe				**$43,693**		**$21,631**		**$3,468**	**$68,792**
Pipe Fittings: Couplings (PVC Fittings)									
1-1/2" PVC Coupling, Schedule 80	6	EA	$2.80	$17	$18.90	$113	$0.00	$0	$130
6" PVC Coupling, Schedule 80	2	EA	$23.00	$46	$37.00	$74	$0.00	$0	$120
8" PVC Coupling, Schedule 80	128	EA	$48.00	$6,144	$49.00	$6,272	$0.00	$0	$12,416
Subtotal: Pipe Fittings: Couplings				**$6,207**		**$6,459**		**$0**	**$12,666**
Pipe Fittings: TEE (PVC Fittings)									
6" PVC Tee, Schedule 80	2	EA	$46.00	$92	$88.50	$177	$0.00	$0	$269
8" PVC Tee, Schedule 80	8	EA	$65.00	$520	$115.00	$920	$0.00	$0	$1,440
Subtotal: Pipe Fittings: TEE				**$612**		**$1,097**		**$0**	**$1,709**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
1-1/2" Shut Off Valve	1	EA	$266	$266	$45	$45	$0.00	$0	$311
6" Shut Off Valve	2	EA	$400	$800	$111	$222	$0.00	$0	$1,022
8" Shut Off Valve	16	EA	$720	$11,520	$166	$2,656	$0.00	$0	$14,176
Subtotal: Shut-Off Valves				**$12,586**		**$2,923**		**$0**	**$15,509**

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate Code A (no design competed)
Location Fort Irwin, California		
Engineer-Architect Keller & Gannon		
Drawing No. **Domestic Water Piping: Area P** - Depot Loop & Road off Langford Rd	Estimator BIH	Checked By RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Fire Hydrants									
Fire Hydrant	5	EA	$785	$3,925	$67	$333	$10.85	$54	$4,312
Subtotal: Fire Hydrants				**$3,925**		**$333**		**$54**	**$4,312**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$6,702**	50.0%	**$16,222**	10.0%	**$352**	**$23,277**
Subtotal				$95,474		$103,314		$53,708	$252,497
California Sales Tax	7.75%	%		$7,399				$4,162	$11,562
Subtotal									$264,059
Contractor OH & Profit	25.0%	%							$66,015
Subtotal									$330,073
Bond	1.5%	%							$4,951
Subtotal									$335,025
Estimating Contingency	20.0%	%							$67,005
Total Probable Construction Cost									$402,030

CONSTRUCTION COST ESTIMATE

Date Prepared: Mar. '97 (Rev. April '97)

Sheet 1 of 2

Project: EEAP, FY 96 Fort Irwin, Water Conservation Study

Project No.: PN 351

Basis for Estimate: **Code A (no design competed)**

Location: Fort Irwin, California

Engineer-Architect: Keller & Gannon

Drawing No.: **Domestic Water Piping: Area Q** - Veh. Maint. Shops North of Langford

Estimator: **BIH**

Checked By: **RCL**

Line Item	Quantity No. Units	Quantity Unit Meas.	Material Per Unit	Material Total	Labor Per Unit	Labor Total	Equipment Per Unit	Equipment Total	Total Cost
Site Survey, Investigation & Demolition									
Survey, Pipeline	10,160	LF	$0.03	$305	$0.54	$5,486	$0.00	$0	$5,791
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	102	EA	$0.00	$0	$25.00	$2,550	$31.40	$3,203	$5,753
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	12,192	LF	$0.38	$4,633	$1.38	$16,825	$1.06	$12,924	$34,381
Saw Cut Concrete (10-inch depth)	4,064	LF	$4.20	$17,069	$6.80	$27,635	$5.20	$21,133	$65,837
Pavement Removal, Bituminous to 6"	2,032	SY	$2.20	$4,470	$2.98	$6,055	$5.18	$10,526	$21,052
Concrete Removal, Rod Reinforced	677	SY	$4.61	$3,123	$6.25	$4,233	$10.86	$7,356	$14,712
Haul Pavements 12 CY Truck 10 mi RT	527	CY	$3.48	$1,833	$8.80	$4,636	$12.28	$6,469	$12,939
Subtotal, Survey, Site Investigation & Demolition				**$31,433**		**$68,588**		**$61,901**	**$161,922**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	611	CY	$0.00	$0	$11.55	$7,063	$0.00	$0	$7,063
Compaction by Roller, Walking	1,834	CY	$0.00	$0	$2.95	$5,412	$0.86	$1,578	$6,989
Trench: 40 HP, Riding, 16"W 36"D	10,160	LF	$0.00	$0	$0.29	$2,946	$0.30	$3,048	$5,994
Backfill Trench, 1 CY Bkt, Min Haul	2,446	CY	$0.00	$0	$0.74	$1,810	$0.58	$1,419	$3,229
Pipe Bedding, Side Slope 1/2:1	10,160	LF	$1.01	$10,262	$1.39	$14,122	$2.40	$24,384	$48,768
Compaction by Vibr. Plate	10,160	LF	$0.00	$0	$0.37	$3,759	$0.29	$2,946	$6,706
Subtotal, Excavation / Backfill / Compaction				**$10,262**		**$35,112**		**$33,375**	**$78,748**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
4" PVC Pipe, Schedule 80	2,320	LF	$3.19	$7,405	$2.76	$6,403	$0.00	$0	$13,809
8" PVC Pipe, Schedule 80	7,840	LF	$8.45	$66,256	$4.15	$32,536	$0.68	$5,331	$104,123
Subtotal, PVC Pipe				**$73,661**		**$38,939**		**$5,331**	**$117,932**
Pipe Fittings: Couplings (PVC Fittings)									
4" PVC Coupling, Schedule 80	58	EA	$10.60	$615	$27.50	$1,595	$0.00	$0	$2,210
8" PVC Coupling, Schedule 80	196	EA	$48.00	$9,408	$49.00	$9,604	$0.00	$0	$19,012
Subtotal: Pipe Fittings: Couplings				**$10,023**		**$11,199**		**$0**	**$21,222**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
6" PVC 45&90° Elbow, Schedule 80	6	EA	$27.50	$165	$63.00	$378	$0.00	$0	$543
8" PVC 45&90° Elbow, Schedule 80	8	EA	$62.00	$496	$86.00	$688	$0.00	$0	$1,184
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$661**		**$1,066**		**$0**	**$1,727**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	13	EA	$65.00	$845	$115.00	$1,495	$0.00	$0	$2,340
Subtotal: Pipe Fittings: TEE				**$845**		**$1,495**		**$0**	**$2,340**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	17	EA	$720	$12,240	$166	$2,822	$0.00	$0	$15,062
Subtotal: Shut-Off Valves				**$12,240**		**$2,822**		**$0**	**$15,062**

F:\PROJ\1640321\ENGR\Newpipe1 Domestic Area Q

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 2 of 2

Project	Project No.	Basis for Estimate
EEAP, FY 96 Fort Irwin, Water Conservation Study	PN 351	Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area Q** - Veh. Maint. Shops North of Langford	Estimator: BIH	Checked By: RCL

Line Item	Quantity No. Units	Quantity Unit Meas.	Material Per Unit	Material Total	Labor Per Unit	Labor Total	Equipment Per Unit	Equipment Total	Total Cost
Fire Hydrants									
Fire Hydrant	6	EA	$785	$4,710	$67	$399	$10.85	$65	$5,174
Subtotal: Fire Hydrants				**$4,710**		**$399**		**$65**	**$5,174**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$10,214**	50.0%	**$27,960**	10.0%	**$540**	**$38,714**
Subtotal				$154,048		$187,581		$101,212	$442,841
California Sales Tax	7.75%	%		$11,939				$7,844	$19,783
Subtotal									$462,624
Contractor OH & Profit	25.0%	%							$115,656
Subtotal									$578,280
Bond	1.5%	%							$8,674
Subtotal									$586,954
Estimating Contingency	20.0%	%							$117,391
Total Probable Construction Cost									$704,345

CONSTRUCTION COST ESTIMATE

Date Prepared	Sheet	of
Mar. '97 (Rev. April '97)	1	2

Project	Project No.	Basis for Estimate
EEAP, FY 96 Fort Irwin, Water Conservation Study	PN 351	**Code A (no design competed)**

Location: Fort Irwin, California

Engineer-Architect: Keller & Gannon

Drawing No.	Estimator	Checked By
Domestic Water Piping: Area R - Lanford Road / Avenue F to ASD	**BIH**	**RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	8,820	LF	$0.03	$265	$0.54	$4,763	$0.00	$0	$5,027
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	88	EA	$0.00	$0	$25.00	$2,200	$31.40	$2,763	$4,963
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	10,584	LF	$0.38	$4,022	$1.38	$14,606	$1.06	$11,219	$29,847
Saw Cut Concrete (10-inch depth)	3,528	LF	$4.20	$14,818	$6.80	$23,990	$5.20	$18,346	$57,154
Pavement Removal, Bituminous to 6"	1,764	SY	$2.20	$3,881	$2.98	$5,257	$5.18	$9,138	$18,275
Concrete Removal, Rod Reinforced	588	SY	$4.61	$2,711	$6.25	$3,675	$10.86	$6,386	$12,771
Haul Pavements 12 CY Truck 10 mi RT	457	CY	$3.48	$1,592	$8.80	$4,025	$12.28	$5,616	$11,232
Subtotal, Survey, Site Investigation & Demolition				**$27,287**		**$59,682**		**$53,758**	**$140,728**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	531	CY	$0.00	$0	$11.55	$6,131	$0.00	$0	$6,131
Compaction by Roller, Walking	1,593	CY	$0.00	$0	$2.95	$4,698	$0.86	$1,370	$6,067
Trench: 40 HP, Riding, 16"W 36"D	8,820	LF	$0.00	$0	$0.29	$2,558	$0.30	$2,646	$5,204
Backfill Trench, 1 CY Bkt, Min Haul	2,123	CY	$0.00	$0	$0.74	$1,571	$0.58	$1,232	$2,803
Pipe Bedding, Side Slope 1/2:1	8,820	LF	$1.01	$8,908	$1.39	$12,260	$2.40	$21,168	$42,336
Compaction by Vibr. Plate	8,820	LF	$0.00	$0	$0.37	$3,263	$0.29	$2,558	$5,821
Subtotal, Excavation / Backfill / Compaction				**$8,908**		**$30,481**		**$28,973**	**$68,362**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
6" PVC Pipe, Schedule 80	200	LF	$5.46	$1,092	$3.07	$614	$0.00	$0	$1,706
8" PVC Pipe, Schedule 80	8,620	LF	$8.45	$72,848	$4.15	$35,773	$0.68	$5,862	$114,482
Subtotal, PVC Pipe				**$73,940**		**$36,387**		**$5,862**	**$116,188**
Pipe Fittings: Couplings (PVC Fittings)									
6" PVC Coupling, Schedule 80	5	EA	$23.00	$115	$37.00	$185	$0.00	$0	$300
8" PVC Coupling, Schedule 80	216	EA	$48.00	$10,368	$49.00	$10,584	$0.00	$0	$20,952
Subtotal: Pipe Fittings: Couplings				**$10,483**		**$10,769**		**$0**	**$21,252**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
8" PVC 45&90° Elbow, Schedule 80	3	EA	$62.00	$186	$86.00	$258	$0.00	$0	$444
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$186**		**$258**		**$0**	**$444**
Pipe Fittings: TEE (PVC Fittings)									
6" PVC Tee, Schedule 80	1	EA	$46.00	$46	$88.50	$89	$0.00	$0	$135
Subtotal: Pipe Fittings: TEE				**$46**		**$89**		**$0**	**$135**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	7	EA	$720	$5,040	$166	$1,162	$0.00	$0	$6,202
Subtotal: Shut-Off Valves				**$5,040**		**$1,162**		**$0**	**$6,202**
Pressure Regulating Valves (Installation, twice Means for Shut-Off Valve + Materials from Watts)									
8" Pressure Regulating Valve	1	EA	$2,683	$2,683	$332	$332	$0.00	$0	$3,015
Subtotal: Pressure Regulating Valves				**$2,683**		**$332**		**$0**	**$3,015**

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area R** - Lanford Road / Avenue F to ASD	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Hand Hole Vaults for PRV's									
Hand Hole for PRV > 6"	1	EA	$570	$570	$177	$177	$72.00	$72	$819
Subtotal: Hand Hole Vaults for PRV's				**$570**		**$177**		**$72**	**$819**
Fire Hydrants									
Fire Hydrant	1	EA	$785	$785	$67	$67	$10.85	$11	$862
Subtotal: Fire Hydrants				**$785**		**$67**		**$11**	**$862**
Water Supply Meters									
Turbine Meter 8"	1	EA	$5,825	$5,825	$325	$325	$0.00	$0	$6,150
Subtotal: Water Supply Meters				**$5,825**		**$325**		**$0**	**$6,150**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$9,956**	50.0%	**$24,783**	10.0%	**$594**	**$35,333**
Subtotal				$145,709		$164,511		$89,270	$399,490
California Sales Tax	7.75%	%		$11,292				$6,918	$18,211
Subtotal									$417,701
Contractor OH & Profit	25.0%	%							$104,425
Subtotal									$522,126
Bond	1.5%	%							$7,832
Subtotal									$529,958
Estimating Contingency	20.0%	%							$105,992
Total Probable Construction Cost									$635,950

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area S** - South Loop Road, Langford to North	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	2,040	LF	$0.03	$61	$0.54	$1,102	$0.00	$0	$1,163
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	20	EA	$0.00	$0	$25.00	$500	$31.40	$628	$1,128
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	2,448	LF	$0.38	$930	$1.38	$3,378	$1.06	$2,595	$6,903
Saw Cut Concrete (10-inch depth)	816	LF	$4.20	$3,427	$6.80	$5,549	$5.20	$4,243	$13,219
Pavement Removal, Bituminous to 6"	408	SY	$2.20	$898	$2.98	$1,216	$5.18	$2,113	$4,227
Concrete Removal, Rod Reinforced	136	SY	$4.61	$627	$6.25	$850	$10.86	$1,477	$2,954
Haul Pavements 12 CY Truck 10 mi RT	106	CY	$3.48	$368	$8.80	$931	$12.28	$1,299	$2,598
Subtotal, Survey, Site Investigation & Demolition				**$6,311**		**$14,692**		**$12,646**	**$33,650**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	123	CY	$0.00	$0	$11.55	$1,418	$0.00	$0	$1,418
Compaction by Roller, Walking	368	CY	$0.00	$0	$2.95	$1,087	$0.86	$317	$1,403
Trench: 40 HP, Riding, 16"W 36"D	2,040	LF	$0.00	$0	$0.29	$592	$0.30	$612	$1,204
Backfill Trench, 1 CY Bkt, Min Haul	491	CY	$0.00	$0	$0.74	$363	$0.58	$285	$648
Pipe Bedding, Side Slope 1/2:1	2,040	LF	$1.01	$2,060	$1.39	$2,836	$2.40	$4,896	$9,792
Compaction by Vibr. Plate	2,040	LF	$0.00	$0	$0.37	$755	$0.29	$592	$1,346
Subtotal, Excavation / Backfill / Compaction				**$2,060**		**$7,050**		**$6,701**	**$15,812**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
8" PVC Pipe, Schedule 80	2,040	LF	$8.45	$17,240	$4.15	$8,466	$0.68	$1,387	$27,093
Subtotal, PVC Pipe				**$17,240**		**$8,466**		**$1,387**	**$27,093**
Pipe Fittings: Couplings (PVC Fittings)									
8" PVC Coupling, Schedule 80	51	EA	$48.00	$2,448	$49.00	$2,499	$0.00	$0	$4,947
Subtotal: Pipe Fittings: Couplings				**$2,448**		**$2,499**		**$0**	**$4,947**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	10	EA	$65.00	$650	$115.00	$1,150	$0.00	$0	$1,800
Subtotal: Pipe Fittings: TEE				**$650**		**$1,150**		**$0**	**$1,800**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	5	EA	$720	$3,600	$166	$830	$0.00	$0	$4,430
Subtotal: Shut-Off Valves				**$3,600**		**$830**		**$0**	**$4,430**
Fire Hydrants									
Fire Hydrant	5	EA	$785	$3,925	$67	$333	$10.85	$54	$4,312
Subtotal: Fire Hydrants				**$3,925**		**$333**		**$54**	**$4,312**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$2,786**	50.0%	**$6,639**	10.0%	**$144**	**$9,570**
Subtotal				$39,021		$41,659		$20,933	$101,614
California Sales Tax	7.75%	%		$3,024				$1,622	$4,646
Subtotal									$106,260
Contractor OH & Profit	25.0%	%							$26,565
Subtotal									$132,825

F:\PROJ\1640321\ENGR\Newpipe1 Domestic Area S

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 2 of 2

Project EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate Code A (no design competed)
Location Fort Irwin, California		
Engineer-Architect Keller & Gannon		
Drawing No. **Domestic Water Piping: Area S** - South Loop Road, Langford to North	Estimator **BIH**	Checked By **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Bond	1.5%	%							$1,992
Subtotal									$134,817
Estimating Contingency	20.0%	%							$26,963
Total Probable Construction Cost									$161,781

CONSTRUCTION COST ESTIMATE

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 1	of 2
Project EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate Code A (no design competed)	
Location Fort Irwin, California			
Engineer-Architect Keller & Gannon			
Drawing No. **Domestic Water Piping: Area T** - 5th - Langford / Ave F to South Loop		Estimator BIH	Checked By RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	9,100	LF	$0.03	$273	$0.54	$4,914	$0.00	$0	$5,187
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	91	EA	$0.00	$0	$25.00	$2,275	$31.40	$2,857	$5,132
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	10,920	LF	$0.38	$4,150	$1.38	$15,070	$1.06	$11,575	$30,794
Saw Cut Concrete (10-inch depth)	3,640	LF	$4.20	$15,288	$6.80	$24,752	$5.20	$18,928	$58,968
Pavement Removal, Bituminous to 6"	1,820	SY	$2.20	$4,004	$2.98	$5,424	$5.18	$9,428	$18,855
Concrete Removal, Rod Reinforced	607	SY	$4.61	$2,797	$6.25	$3,792	$10.86	$6,588	$13,177
Haul Pavements 12 CY Truck 10 mi RT	472	CY	$3.48	$1,642	$8.80	$4,152	$12.28	$5,794	$11,589
Subtotal, Survey, Site Investigation & Demolition				**$28,153**		**$61,545**		**$55,462**	**$145,160**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	548	CY	$0.00	$0	$11.55	$6,326	$0.00	$0	$6,326
Compaction by Roller, Walking	1,643	CY	$0.00	$0	$2.95	$4,847	$0.86	$1,413	$6,260
Trench: 40 HP, Riding, 16"W 36"D	9,100	LF	$0.00	$0	$0.29	$2,639	$0.30	$2,730	$5,369
Backfill Trench, 1 CY Bkt, Min Haul	2,191	CY	$0.00	$0	$0.74	$1,621	$0.58	$1,271	$2,892
Pipe Bedding, Side Slope 1/2:1	9,100	LF	$1.01	$9,191	$1.39	$12,649	$2.40	$21,840	$43,680
Compaction by Vibr. Plate	9,100	LF	$0.00	$0	$0.37	$3,367	$0.29	$2,639	$6,006
Subtotal, Excavation / Backfill / Compaction				**$9,191**		**$31,449**		**$29,893**	**$70,533**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
4" PVC Pipe, Schedule 80	2,800	LF	$3.19	$8,938	$2.76	$7,728	$0.00	$0	$16,666
8" PVC Pipe, Schedule 80	6,300	LF	$8.45	$53,241	$4.15	$26,145	$0.68	$4,284	$83,670
Subtotal, PVC Pipe				**$62,179**		**$33,873**		**$4,284**	**$100,336**
Pipe Fittings: Couplings (PVC Fittings)									
4" PVC Coupling, Schedule 80	70	EA	$10.60	$742	$27.50	$1,925	$0.00	$0	$2,667
8" PVC Coupling, Schedule 80	158	EA	$48.00	$7,584	$49.00	$7,742	$0.00	$0	$15,326
Subtotal: Pipe Fittings: Couplings				**$8,326**		**$9,667**		**$0**	**$17,993**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
8" PVC 45&90° Elbow, Schedule 80	1	EA	$62.00	$62	$86.00	$86	$0.00	$0	$148
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$62**		**$86**		**$0**	**$148**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	14	EA	$65.00	$910	$115.00	$1,610	$0.00	$0	$2,520
Subtotal: Pipe Fittings: TEE				**$910**		**$1,610**		**$0**	**$2,520**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	8	EA	$720	$5,760	$166	$1,328	$0.00	$0	$7,088
Subtotal: Shut-Off Valves				**$5,760**		**$1,328**		**$0**	**$7,088**

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area T** - 5th - Langford / Ave F to South Loop	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Fire Hydrants									
Fire Hydrant	12	EA	$785	$9,420	$67	$798	$10.85	$130	$10,348
Subtotal: Fire Hydrants				**$9,420**		**$798**		**$130**	**$10,348**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$8,666**	50.0%	**$23,681**	10.0%	**$441**	**$32,789**
Subtotal				$132,667		$164,037		$90,210	$386,915
California Sales Tax	7.75%	%		$10,282				$6,991	$17,273
Subtotal									$404,188
Contractor OH & Profit	25.0%	%							$101,047
Subtotal									$505,235
Bond	1.5%	%							$7,579
Subtotal									$512,813
Estimating Contingency	20.0%	%							$102,563
Total Probable Construction Cost									$615,376

CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 1	of 2
Project EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate Code A (no design competed)	
Location Fort Irwin, California			
Engineer-Architect Keller & Gannon			
Drawing No. **Domestic Water Piping: Area U** - Langford Road to Avenue F		Estimator **BIH**	Checked By **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	2,550	LF	$0.03	$77	$0.54	$1,377	$0.00	$0	$1,454
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	26	EA	$0.00	$0	$25.00	$650	$31.40	$816	$1,466
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	3,060	LF	$0.38	$1,163	$1.38	$4,223	$1.06	$3,244	$8,629
Saw Cut Concrete (10-inch depth)	1,020	LF	$4.20	$4,284	$6.80	$6,936	$5.20	$5,304	$16,524
Pavement Removal, Bituminous to 6"	510	SY	$2.20	$1,122	$2.98	$1,520	$5.18	$2,642	$5,284
Concrete Removal, Rod Reinforced	170	SY	$4.61	$784	$6.25	$1,063	$10.86	$1,846	$3,692
Haul Pavements 12 CY Truck 10 mi RT	132	CY	$3.48	$460	$8.80	$1,164	$12.28	$1,624	$3,247
Subtotal, Survey, Site Investigation & Demolition				**$7,889**		**$18,099**		**$15,767**	**$41,754**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	153	CY	$0.00	$0	$11.55	$1,773	$0.00	$0	$1,773
Compaction by Roller, Walking	460	CY	$0.00	$0	$2.95	$1,358	$0.86	$396	$1,754
Trench: 40 HP, Riding, 16"W 36"D	2,550	LF	$0.00	$0	$0.29	$740	$0.30	$765	$1,505
Backfill Trench, 1 CY Bkt, Min Haul	614	CY	$0.00	$0	$0.74	$454	$0.58	$356	$810
Pipe Bedding, Side Slope 1/2:1	2,550	LF	$1.01	$2,576	$1.39	$3,545	$2.40	$6,120	$12,240
Compaction by Vibr. Plate	2,550	LF	$0.00	$0	$0.37	$944	$0.29	$740	$1,683
Subtotal, Excavation / Backfill / Compaction				**$2,576**		**$8,813**		**$8,377**	**$19,765**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
8" PVC Pipe, Schedule 80	2,550	LF	$8.45	$21,550	$4.15	$10,583	$0.68	$1,734	$33,867
Subtotal, PVC Pipe				**$21,550**		**$10,583**		**$1,734**	**$33,867**
Pipe Fittings: Couplings (PVC Fittings)									
8" PVC Coupling, Schedule 80	64	EA	$48.00	$3,072	$49.00	$3,136	$0.00	$0	$6,208
Subtotal: Pipe Fittings: Couplings				**$3,072**		**$3,136**		**$0**	**$6,208**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	5	EA	$65.00	$325	$115.00	$575	$0.00	$0	$900
Subtotal: Pipe Fittings: TEE				**$325**		**$575**		**$0**	**$900**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	3	EA	$720	$2,160	$166	$498	$0.00	$0	$2,658
Subtotal: Shut-Off Valves				**$2,160**		**$498**		**$0**	**$2,658**

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area U** - Langford Road to Avenue F	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Fire Hydrants									
Fire Hydrant	1	EA	$785	$785	$67	$67	$10.85	$11	$862
Subtotal: Fire Hydrants				**$785**		**$67**		**$11**	**$862**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$2,789**	50.0%	**$7,429**	10.0%	**$174**	**$10,393**
Subtotal				$41,146		$49,198		$26,063	$116,407
California Sales Tax	7.75%	%		$3,189				$2,020	$5,209
Subtotal									$121,616
Contractor OH & Profit	25.0%	%							$30,404
Subtotal									$152,020
Bond	1.5%	%							$2,280
Subtotal									$154,300
Estimating Contingency	20.0%	%							$30,860
Total Probable Construction Cost									$185,160

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area V - 5th - Langford / Ave F - Ave G**	Estimator: **BIH**	Checked By: **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	7,800	LF	$0.03	$234	$0.54	$4,212	$0.00	$0	$4,446
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	78	EA	$0.00	$0	$25.00	$1,950	$31.40	$2,449	$4,399
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	9,360	LF	$0.38	$3,557	$1.38	$12,917	$1.06	$9,922	$26,395
Saw Cut Concrete (10-inch depth)	3,120	LF	$4.20	$13,104	$6.80	$21,216	$5.20	$16,224	$50,544
Pavement Removal, Bituminous to 6"	1,560	SY	$2.20	$3,432	$2.98	$4,649	$5.18	$8,081	$16,162
Concrete Removal, Rod Reinforced	520	SY	$4.61	$2,397	$6.25	$3,250	$10.86	$5,647	$11,294
Haul Pavements 12 CY Truck 10 mi RT	404	CY	$3.48	$1,407	$8.80	$3,559	$12.28	$4,967	$9,933
Subtotal, Survey, Site Investigation & Demolition				**$24,131**		**$52,920**		**$47,580**	**$124,632**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	469	CY	$0.00	$0	$11.55	$5,422	$0.00	$0	$5,422
Compaction by Roller, Walking	1,408	CY	$0.00	$0	$2.95	$4,155	$0.86	$1,211	$5,366
Trench: 40 HP, Riding, 16"W 36"D	7,800	LF	$0.00	$0	$0.29	$2,262	$0.30	$2,340	$4,602
Backfill Trench, 1 CY Bkt, Min Haul	1,878	CY	$0.00	$0	$0.74	$1,390	$0.58	$1,089	$2,479
Pipe Bedding, Side Slope 1/2:1	7,800	LF	$1.01	$7,878	$1.39	$10,842	$2.40	$18,720	$37,440
Compaction by Vibr. Plate	7,800	LF	$0.00	$0	$0.37	$2,886	$0.29	$2,262	$5,148
Subtotal, Excavation / Backfill / Compaction				**$7,878**		**$26,956**		**$25,622**	**$60,457**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
8" PVC Pipe, Schedule 80	6,400	LF	$8.45	$54,086	$4.15	$26,560	$0.68	$4,352	$84,998
10" PVC Pipe, Schedule 80	1,400	LF	$29.70	$41,580	$5.19	$7,266	$0.85	$1,190	$50,036
Subtotal, PVC Pipe				**$95,666**		**$33,826**		**$5,542**	**$135,034**
Pipe Fittings: Couplings (PVC Fittings)									
8" PVC Coupling, Schedule 80	160	EA	$48.00	$7,680	$49.00	$7,840	$0.00	$0	$15,520
10" PVC Coupling, Schedule 80	35	EA	$55.00	$1,925	$112.00	$53	$0.00	$0	$1,978
Subtotal: Pipe Fittings: Couplings				**$9,605**		**$7,893**		**$0**	**$17,498**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
8" PVC 45&90° Elbow, Schedule 80	1	EA	$62.00	$62	$86.00	$86	$0.00	$0	$148
10" PVC 45&90° Elbow, Sch 80	1	EA	$89.50	$90	$149.00	$149	$0.00	$0	$239
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$152**		**$235**		**$0**	**$387**
Pipe Fittings: TEE (PVC Fittings)									
8" PVC Tee, Schedule 80	34	EA	$65.00	$2,210	$115.00	$3,910	$0.00	$0	$6,120
10" PVC Tee, Sch 80	2	EA	$111.00	$222	$203.50	$407	$0.00	$0	$629
Subtotal: Pipe Fittings: TEE				**$2,432**		**$4,317**		**$0**	**$6,749**
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
8" Shut Off Valve	10	EA	$720	$7,200	$166	$1,660	$0.00	$0	$8,860
Subtotal: Shut-Off Valves				**$7,200**		**$1,660**		**$0**	**$8,860**

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: Code A (no design competed)
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area V** - 5th - Langford / Ave F - Ave G	Estimator: **BIH**	Checked By: **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Fire Hydrants									
Fire Hydrant	10	EA	$785	$7,850	$67	$665	$10.85	$109	$8,624
Subtotal: Fire Hydrants				**$7,850**		**$665**		**$109**	**$8,624**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$12,290**	50.0%	**$24,298**	10.0%	**$565**	**$37,154**
Subtotal				$167,205		$152,770		$79,418	$399,394
California Sales Tax	7.75%	%		$12,958				$6,155	$19,113
Subtotal									$418,507
Contractor OH & Profit	25.0%	%							$104,627
Subtotal									$523,134
Bond	1.5%	%							$7,847
Subtotal									$530,981
Estimating Contingency	20.0%	%							$106,196
Total Probable Construction Cost									$637,177

CONSTRUCTION COST ESTIMATE	Date Prepared: Mar. '97 (Rev. April '97)	Sheet 1 of 2
Project: EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No.: PN 351	Basis for Estimate: **Code A (no design competed)**
Location: Fort Irwin, California		
Engineer-Architect: Keller & Gannon		
Drawing No.: **Domestic Water Piping: Area W** - 5th from S. Loop Treatment Plant	Estimator: BIH	Checked By: RCL

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Site Survey, Investigation & Demolition									
Survey, Pipeline	3,040	LF	$0.03	$91	$0.54	$1,642	$0.00	$0	$1,733
Drawing showing Boring Details	1	EA	$0.00	$0	$170	$170	$0	$0	$170
Field Stake-out, Elevations	1	EA	$0.00	$0	$390	$390	$0	$0	$390
Auger holes, 4 Ft Deep, 1/100 LF	30	EA	$0.00	$0	$25.00	$750	$31.40	$942	$1,692
Report & Recs from Engineer	1	EA	$0.00	$0	$375.00	$375	$0.00	$0	$375
Mobilization/Demobilization, min	1	EA	$0.00	$0	$123	$123	$154	$154	$277
Mobilization >100 miles	100	Mi	$0.00	$0	$1.09	$109	$1.37	$137	$246
Saw Cut Asphalt Road (6" depth)	3,648	LF	$0.38	$1,386	$1.38	$5,034	$1.06	$3,867	$10,287
Saw Cut Concrete (10-inch depth)	1,216	LF	$4.20	$5,107	$6.80	$8,269	$5.20	$6,323	$19,699
Pavement Removal, Bituminous to 6"	608	SY	$2.20	$1,338	$2.98	$1,812	$5.18	$3,149	$6,299
Concrete Removal, Rod Reinforced	203	SY	$4.61	$934	$6.25	$1,267	$10.86	$2,201	$4,402
Haul Pavements 12 CY Truck 10 mi RT	158	CY	$3.48	$549	$8.80	$1,387	$12.28	$1,936	$3,871
Subtotal, Survey, Site Investigation & Demolition				**$9,405**		**$21,327**		**$18,709**	**$49,442**
Excavation / Backfill / Compaction (Assumed that 25% of excavation must be by hand))									
Excavate/Backfill by Hand	183	CY	$0.00	$0	$11.55	$2,113	$0.00	$0	$2,113
Compaction by Roller, Walking	549	CY	$0.00	$0	$2.95	$1,619	$0.86	$472	$2,091
Trench: 40 HP, Riding, 16"W 36"D	3,040	LF	$0.00	$0	$0.29	$882	$0.30	$912	$1,794
Backfill Trench, 1 CY Bkt, Min Haul	732	CY	$0.00	$0	$0.74	$542	$0.58	$424	$966
Pipe Bedding, Side Slope 1/2:1	3,040	LF	$1.01	$3,070	$1.39	$4,226	$2.40	$7,296	$14,592
Compaction by Vibr. Plate	3,040	LF	$0.00	$0	$0.37	$1,125	$0.29	$882	$2,006
Subtotal, Excavation / Backfill / Compaction				**$3,070**		**$10,506**		**$9,986**	**$23,563**
Piping (PVC Piping is selected as it is preferred by Water Distribution System operators at Fort Irwin)									
2" PVC Pipe, Schedule 80	1,000	LF	$1.47	$1,473	$2.21	$2,210	$0.00	$0	$3,683
3" PVC Pipe, Schedule 80	40	LF	$2.64	$106	$2.76	$110	$0.00	$0	$216
6" PVC Pipe, Schedule 80	700	LF	$5.46	$3,822	$3.07	$2,149	$0.00	$0	$5,971
8" PVC Pipe, Schedule 80	1,300	LF	$8.45	$10,986	$4.15	$5,395	$0.68	$884	$17,265
Subtotal, PVC Pipe				**$16,387**		**$9,864**		**$884**	**$27,135**
Pipe Fittings: Couplings (PVC Fittings)									
2" PVC Coupling, Schedule 80	50	EA	$3.00	$150	$20.00	$1,000	$0.00	$0	$1,150
3" PVC Coupling, Schedule 80	1	EA	$8.40	$8	$23.50	$24	$0.00	$0	$32
6" PVC Coupling, Schedule 80	18	EA	$23.00	$414	$37.00	$666	$0.00	$0	$1,080
8" PVC Coupling, Schedule 80	33	EA	$48.00	$1,584	$49.00	$1,617	$0.00	$0	$3,201
Subtotal: Pipe Fittings: Couplings				**$2,156**		**$3,307**		**$0**	**$5,463**
Pipe Fittings: 45° & 90° Elbows (PVC Fittings)									
2" PVC 45&90° Elbow, Schedule 80	1	EA	$3.12	$3	$20.00	$20	$0.00	$0	$23
8" PVC 45&90° Elbow, Schedule 80	5	EA	$62.00	$310	$86.00	$430	$0.00	$0	$740
Subtotal: Pipe Fittings: 45° & 90° Elbows				**$313**		**$450**		**$0**	**$763**
Pipe Fittings: TEE (PVC Fittings)									
2" PVC Tee, Schedule 80	1	EA	$11.15	$11	$31.50	$32	$0.00	$0	$43
4" PVC Tee, Schedule 80	1	EA	$17.55	$18	$55.50	$56	$0.00	$0	$73
8" PVC Tee, Schedule 80	6	EA	$65.00	$390	$115.00	$690	$0.00	$0	$1,080
Subtotal: Pipe Fittings: TEE				**$419**		**$777**		**$0**	**$1,196**

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CONSTRUCTION COST ESTIMATE	Date Prepared Mar. '97 (Rev. April '97)	Sheet 2 of 2
Project EEAP, FY 96 Fort Irwin, Water Conservation Study	Project No. PN 351	Basis for Estimate **Code A (no design competed)**
Location Fort Irwin, California		
Engineer-Architect Keller & Gannon		
Drawing No. **Domestic Water Piping: Area W** - 5th from S. Loop Treatment Plant	Estimator **BIH**	Checked By **RCL**

Line Item	Quantity		Material		Labor		Equipment		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	Per Unit	Total	
Shut-Off Valves: Gate (2"-4") **& Butterfly** (6" and larger); including Street Box									
2" Shut Off Valve	2	EA	$266	$531	$45	$91	$0.00	$0	$622
8" Shut Off Valve	8	EA	$720	$5,760	$166	$1,328	$0.00	$0	$7,088
Subtotal: Shut-Off Valves				**$6,291**		**$1,419**		**$0**	**$7,710**
Fire Hydrants									
Fire Hydrant	5	EA	$785	$3,925	$67	$333	$10.85	$54	$4,312
Subtotal: Fire Hydrants				**$3,925**		**$333**		**$54**	**$4,312**
Mechanical Subcontractors Overhead & Profit		%	10.0%	**$2,949**	50.0%	**$8,074**	10.0%	**$94**	**$11,118**
Subtotal				$44,916		$56,057		$29,727	$130,700
California Sales Tax	7.75%	%		$3,481				$2,304	$5,785
Subtotal									$136,485
Contractor OH & Profit	25.0%	%							$34,121
Subtotal									$170,606
Bond	1.5%	%							$2,559
Subtotal									$173,166
Estimating Contingency	20.0%	%							$34,633
Total Probable Construction Cost									$207,799

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